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1987 Lake Winnipegosis fish stock assessment

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ABSTRACT

Productivity of hatchery-stocked walleye from Steeprock rearing pond was 53.4 kg. during 33 days. During this period, 2,898,014 small walleyes were flushed from the pond into Lake Winnipegosis.

Walleye stocks are presently dominated by the 1983 and 1984 cohorts. Walleye growth and maturity regimes are displaying the maximal amounts of compensation in response to continual fishing stress.

Since 1963, more opportunistic, shorter-lived species such as pike and suckers have become dominant. During its history, the Lake Winnipegosis fishery has displayed major changes in productivity, size of dominant species and species diversity.

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INTRODUCTION

The fish stocks of Lake Winnipegosis have been exploited by commercial fishermen since the 1880s. Sailboats were used by early fishermen who harvested fish with gillnets during the open water season. Winter fisheries began developing during the turn of the century with the advent of the jigger which facilitated setting gillnets under the ice. Horse drawn sleds were used to transport fish to railway stations. The gasoline engine replaced sails in the 1920s. Exploitation of fish stocks increased concomitantly with the development of road and railway systems.

Whitefish, goldeye and sturgeon were the prime species sought by early commercial fishermen in all of the large southern Manitoban lakes since they were amenable to early preservation techniques such as salting and smoking. Slow growth and maturity rates led rapidly to the decline of sturgeon. Walleyes and saugers were culled as "rough" fish during the beginning of commercial fisheries but became the prime species when refrigeration and rapid transportation were introduced.

As demands from southern markets increased, fish stocks were "fished up" from 1950-1965. Exploitation increased with entry of new fishermen, increases in daily yardage allowance, season lengths, creation of new seasons and technological improvements such as the replacement of cotton gillnets by nylon gillnets. Uncontrolled

increasing exploitation caused a decline in the abundance of Lake Winnipegosis' walleye stocks from 1962 to the present time. Pike and sucker abundance increased during this time period.

Many of the economic problems created by the private fish companies who bought fish from fishermen were eliminated by the creation of the Freshwater Fish Marketing Corporation in 1969. This governmental agency now has exclusive control over the freshwater fish trade in western Canada. Value differentials ($/kg) among fish species and the use of multispecies quotas combine to make walleye the most valued, the most sought and the least abundant commercial fish species in Lake Winnipegosis.

The objectives of this report are:

a. to evaluate the survival and production of y-o-y walleye from the Steeprock rearing pond during 1987

b. to describe the fish community species composition and stock dynamics determined during the 1987 experimental gillnetting program

c. to re-evaluate commercial quotas by examining catch and effort relationships from Lake Winnipegosis.

METHODS

Steeprock walleye rearing pond

Steeprock rearing pond covers about 100 acres and is located on the southwestern shore of Dawson Bay (Fig. 1). A small creek on the pond's southern shore provides a supply of fresh water and is controlled by a manual valve with an 18 inch diameter. The western third of the pond is densely vegetated with submerged and emergent vegetation. A man-made earthen dyke borders the northern shore of the pond. This dyke contains an outflow culvert and a manual valve whose diameter is 30 inches.

During the winter of 1986-87, about 100 alfalfa hay bales were spread on the ice over Steeprock Pond to promote rapid plankton production after vernal melting. In mid- May, 1988, 11,000,000 newly-hatched walleye fry were transported to Steeprock Pond from the Grand Rapids hatchery.

Release of these walleye fry into Dawson Bay commenced on June 5 and ended on July 10. To determine survival and production of walleye fry, the pond's outflow was sampled with a conical net. The net had an 18 inch diameter mouth and was 8 feet long. The net's mouth was held open by two stainless steel hoops sewn into the net at a 2 foot interval. The posterior part of the net was conical and terminated in a plastic collection bucket. The net was made of 0.25 inch square nylon

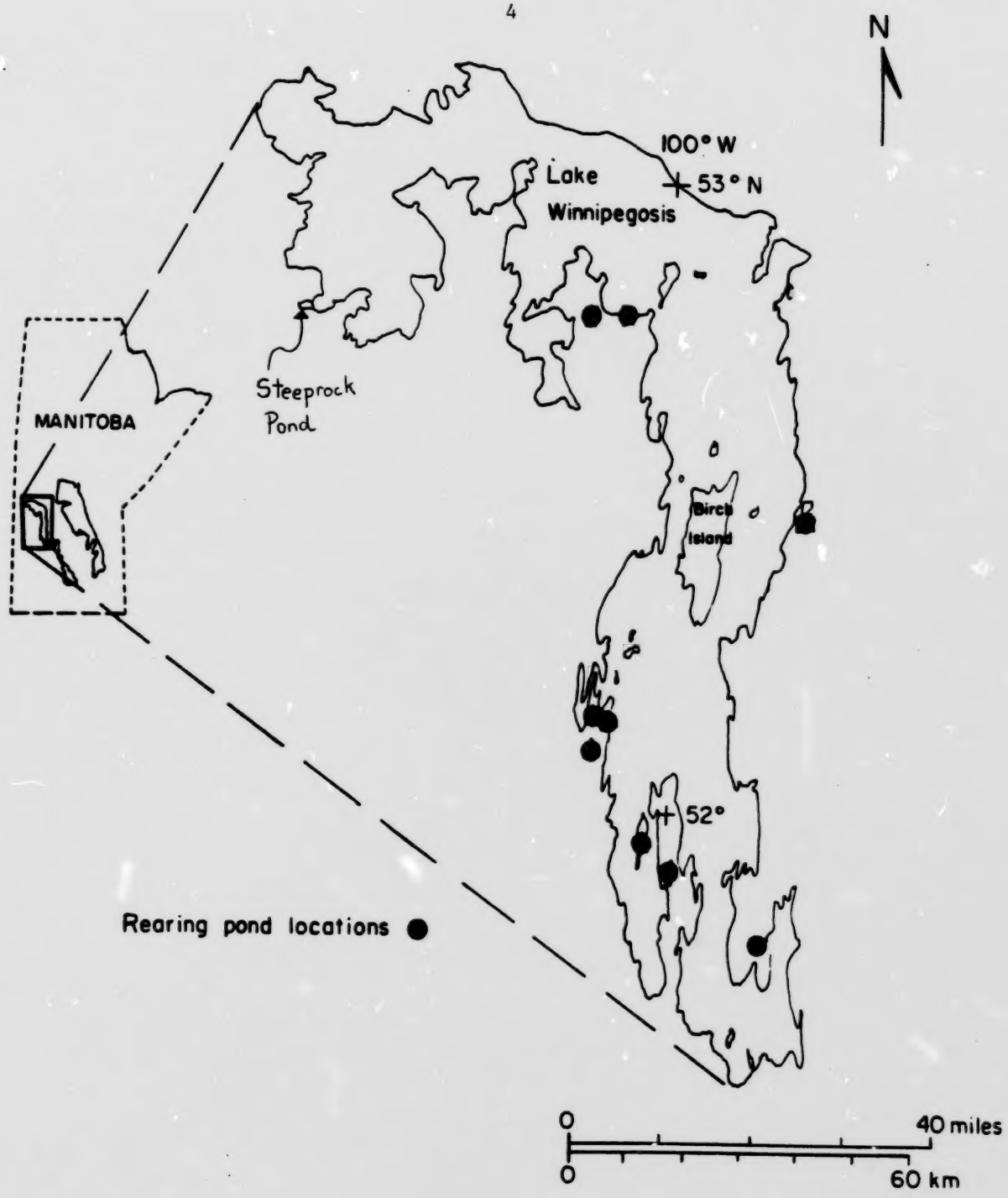

Fig. 1. Location of walleye rearing ponds developed near Lake Winnipegosis, Manitoba.

mesh. While in use, the net was held horizontally with a 3 point bridle and a dorsally suspended metal wing depressor. The net was outfitted with a digital flowmeter (General Oceanics Inc., 1295 N.W. 163rd St., Miami, Florida, 33169, U.S.A.) attached to the steel hoop with 2 thin nylon bridles so that the flowmeter was suspended at the center of the net's mouth. The volume of water flowing through the net during each sample was calculated according to the following formulae:

$$\text{sampled volume } (m^3) = \frac{\pi(\text{diameter}(m))^2}{4} \quad \text{flow distance (m)}$$

$$\text{where flow distance (m)} = \frac{\text{difference in flowmeter counts} \cdot \text{rotor constant}}{99999}$$

and rotor constant = 26873

During the first few days of monitoring, samples of various durations were taken at various times of the day and night to determine whether daylight affected walleyes' movements through the outflow culvert. Three minute sampling durations were chosen since they consistently provided some netted walleyes while minimizing sampling removal of fish from the pond's contribution to the lake. During daylight hours, a mean of 0.27 walleye/m^3/minute were caught. After sunset and until midnight, the sampled mean increased four times to 1.12 fish/m^3/minute. Thereafter, to conserve pond water, the pond was flushed for 4 to 5 hours each evening, commencing at dusk. Six three minute samples of walleyes flushing through the culvert were collected each evening. The height of water flowing through the

culvert was measured each evening. Sampled walleyes were preserved in a 5% formalin solution. Numbers of walleyes per sample were determined. The fork length (mm) and preserved weight (gm) of each sampled walleye were determined.

To determine numbers of walleyes flushed into the lake during each sampling day, the relationships depicted in Fig. 2 were considered while determining the ratio of sampled cross sectional area of water : total cross sectional area of water.

$\emptyset$ = central angle measured in radians

$\emptyset = S/R = 2 \cos^{-1} d/R$

$S = R\,\emptyset = D \cos^{-1} d/R$

$1 = 2\sqrt{R^2 - d^2} = 2 R \sin \emptyset/2$

Area (sector) = $1/2\ RS = 1/2\ R^2\emptyset$

Area (segment) = Area (sector)-Area (triangle)$=1/2R^2(\emptyset-\sin\emptyset)$

Mean numbers of sampled walleyes/m^3/minute were extrapolated to estimate total numbers of walleyes flushed through the culvert during each evening's flushing duration.

Experimental gillnetting

Experimental gangs of gillnets were set at locations marked on Fig. 3 during the open water season of 1987. The gang was composed of six 100 yard nets: 3 inch mesh - 50 meshes deep, 3.25 inch mesh - 50 meshes deep, 3.5 inch mesh - 40 meshes deep, 3.75 inch mesh - 12 meshes

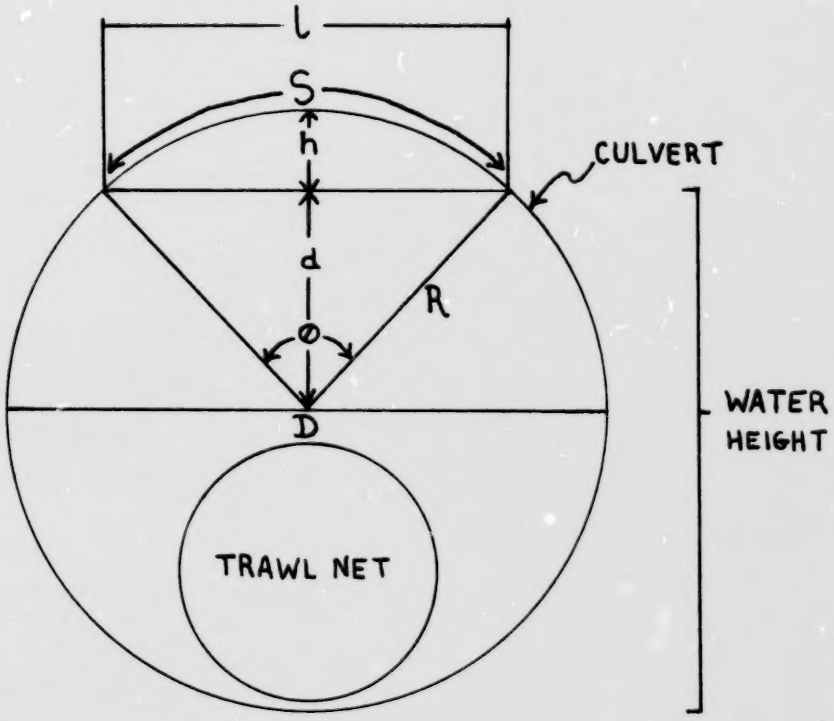

Fig.2. Cross-sectional representation of the pond water flushing through the outflow culvert and the sampling net.

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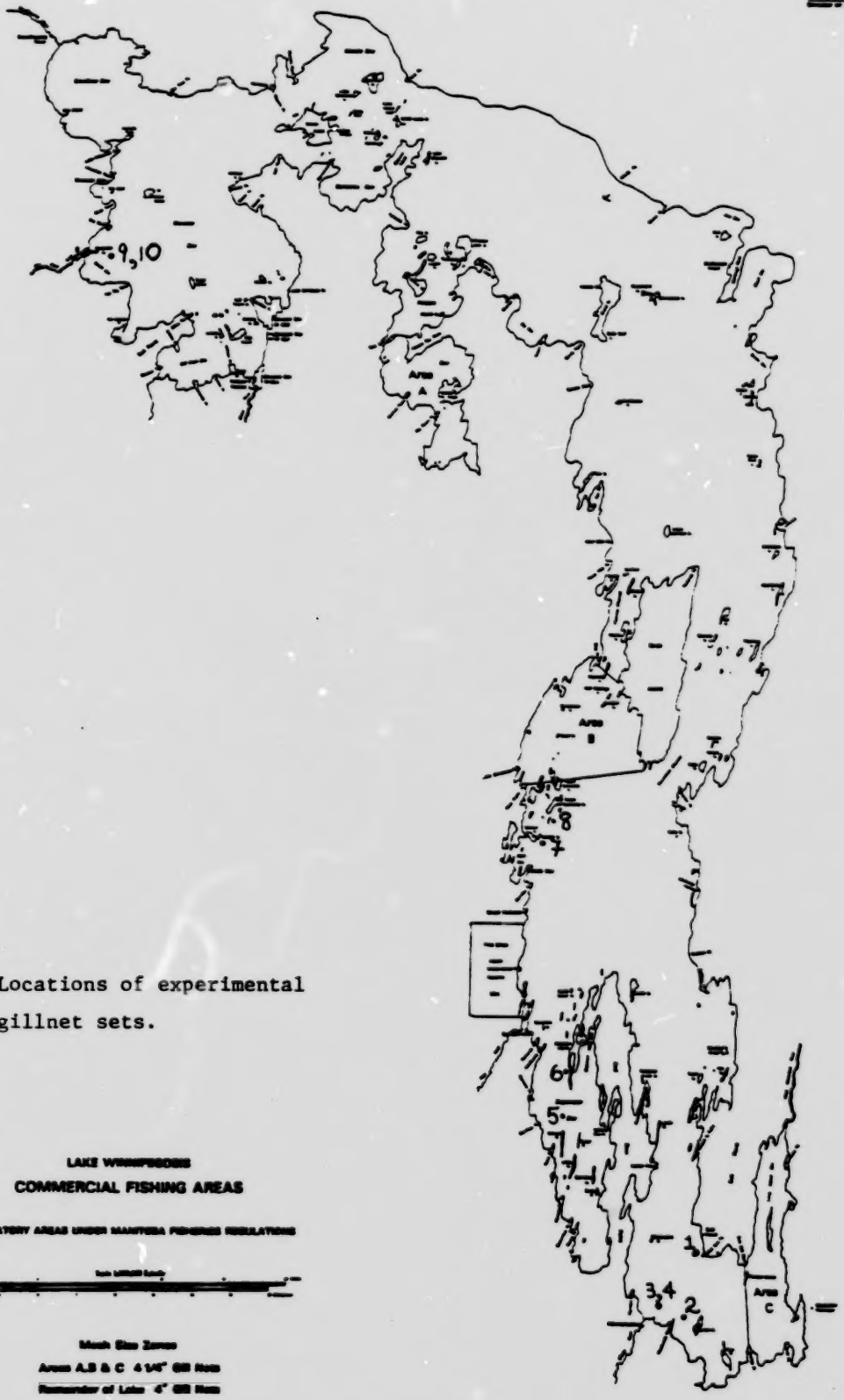


Fig.3. Locations of experimental gillnet sets.

deep. Each gang was set for an overnight (16-18 hours) period.

The numbers and total weights of all species caught during each set were recorded.

All walleyes and some fish of each other species caught in the gillnets were processed as follows: The fork length of each fish was measured to the nearest millimeter. The weight was determined to the nearest five grams on a Chatillon spring scale. Six to ten scales were collected from the left side of each fish except pike. Scales were removed above the lateral line below the anterior edge of the dorsal fin. The left cleithrum was collected from each pike for age determination. Otoliths were collected from walleyes for otolith and scale age comparisons.

Commercial catches of walleyes were sampled during the 1987-1988 winter fishery on Lake Winnipegosis. The scale age, fork length and weight of each commercially caught walleye was determined.

Scale ages were determined using a microfiche reader at 24x and 48x. Thin sections of embedded walleye otoliths were cut with an Isomet low speed saw, mounted on glass slides and read at 24x or 48x.

Lake volume and surface area were estimated by planimetry of 1 fathom contour intervals on the navigational charts of Lake Winnipegosis.

RESULTS

Lake Winnipegosis contains approximately 1.97719×10^{10} cubic meters of water. The surface area and mean depth are 466,151.3 ha. and 4.242 meters, respectively (Table 1).

Numbers of walleye fry flushed from Steeprock Pond decreased rapidly during the first few days and fluctuated thereafter (Fig. 4). No walleyes were captured 33 days after flushing commenced. Mean weights of walleyes increased ten times during June from 0.063 gm to 0.630 gm (Table 2, Fig. 5). The Allen curve estimate of production during 33 days is 53.439 kg (Fig. 6). 2,898,014 walleyes were flushed from the rearing pond during June. Given that 11,000,000 newly hatched fry were stocked in the pond and that all survivors were flushed from the pond, the survival rate was 26%.

(Gerry Edwards provided similar data collected from the North Burrell rearing pond during 6 sampling days. 34,720 walleyes were flushed from North Burrell Pond during July 21 - Aug. 13. This represents a survival rate of 4.96%).

Three and four year old (1983 and 1984 cohorts) walleyes dominated the experimental gillnet catches in 1987 (Table 3, Fig. 7). The equation fitted to the maturity data of walleye females (Table 4, Fig. 8) is:

$$\log (100 - y/y) = -7.99 + 1.84 \text{ (age)}$$

where y = frequency (%) of mature females

Table 1. Morphometry of Lake Winnipegosis.

Depth (feet)	Contour area (m^2)	Volume (m^3)
0	4661512660	
		7647822866
6	3719917650	
		5783772137
12	2636296530	
		3913266266
18	1679125020	
		1929543846
24	536765000	
		464392171.7
30	54303370	
		33103400.57
36	0	
		$\Sigma = 1.97719.10^{10}$
		mean depth = 4.2415 meters

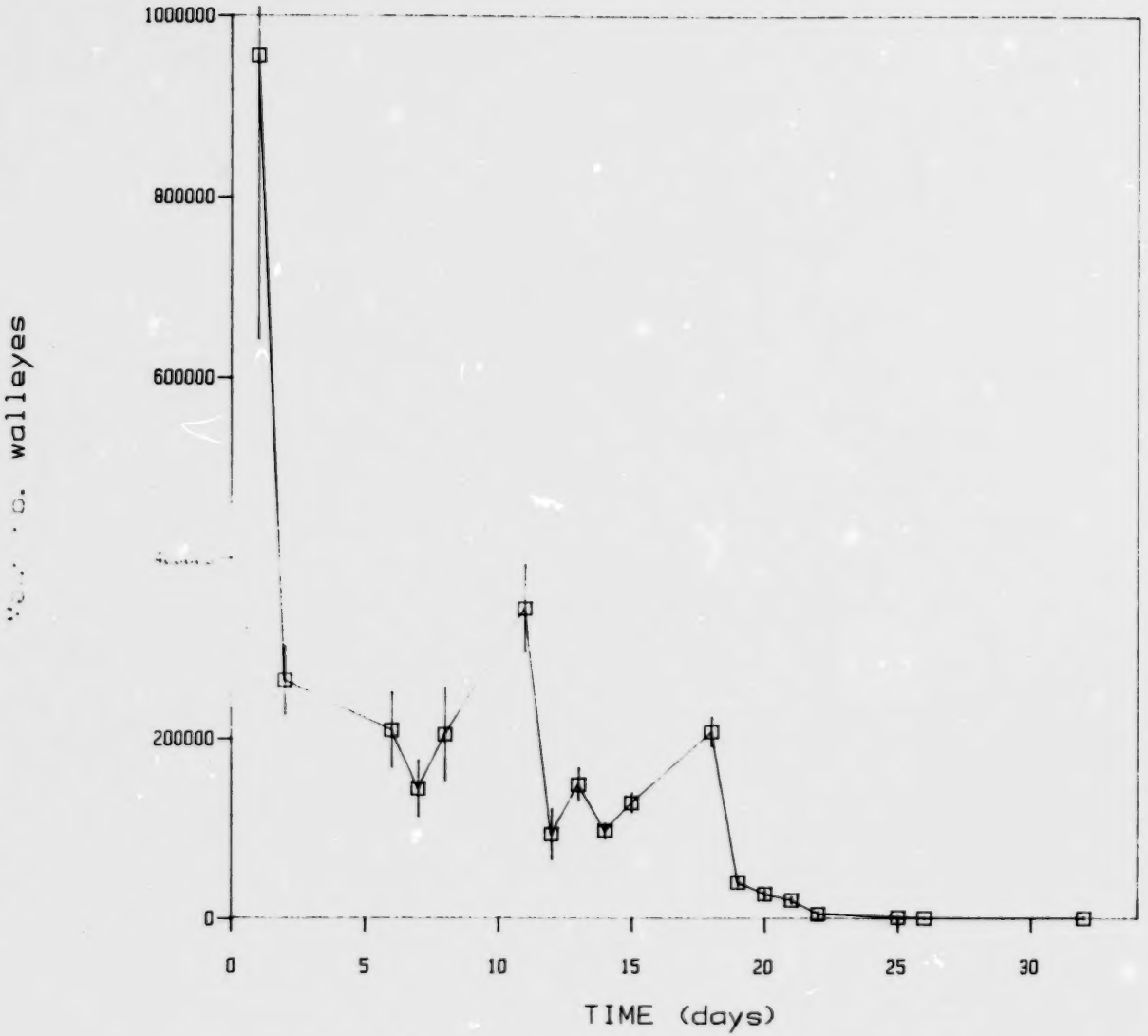


Fig. 4. Temporal changes in numbers of walleyes flushed from Steeprock Pond.

Table 2. Temporal changes in numbers and sizes of walleyes flushed from Steeprock Pond.

Date	Time (days)	Mean no. walleyes	1S.E.	Mean individual weight (gm)	1S.E.
June 5	1	956225	314277.8	0.063	0.002
6	2	264333	38134.01	0.073	0.002
10	6	209269	41906.07	0.117	0.002
11	7	144409	31018.93	0.128	0.003
12	8	204993	51862.75	0.142	0.003
15	11	343967	48497.96	0.172	0.009
16	12	93774	27937.24	0.197	0.009
17	13	149181	17992.17	0.215	0.009
18	14	97694	8656.38	0.233	0.005
19	15	129044	10808.69	0.230	0.003
22	18	208183	16282.57	0.290	0.008
23	19	40499	4098.18	0.313	0.013
24	20	27407	4606.11	0.340	0.022
25	21	20651	3885.02	0.340	0.029
26	22	5225	2430.35	0.374	0.109
29	25	1530	967.49	0.630	0.110
30	26	746	746.48	0.500	---
July 2	28	0	---	---	---
3	29	0	---	---	---
6	32	884	883.83	0.570	---
7	33	0	---	---	---
		Σ =2898014			

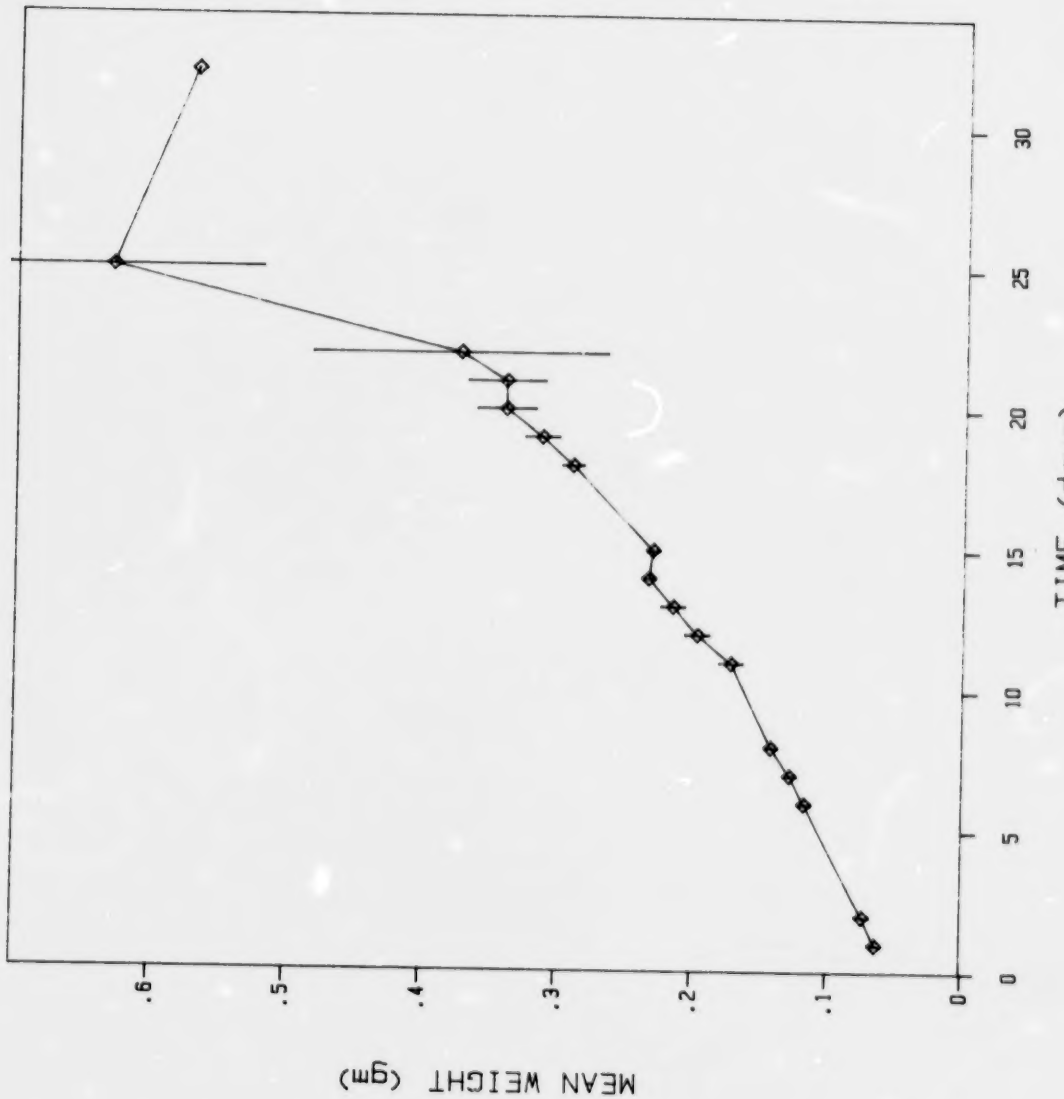


Fig. 5. Temporal changes in sizes of walleyes flushed from Steeprock Pond.

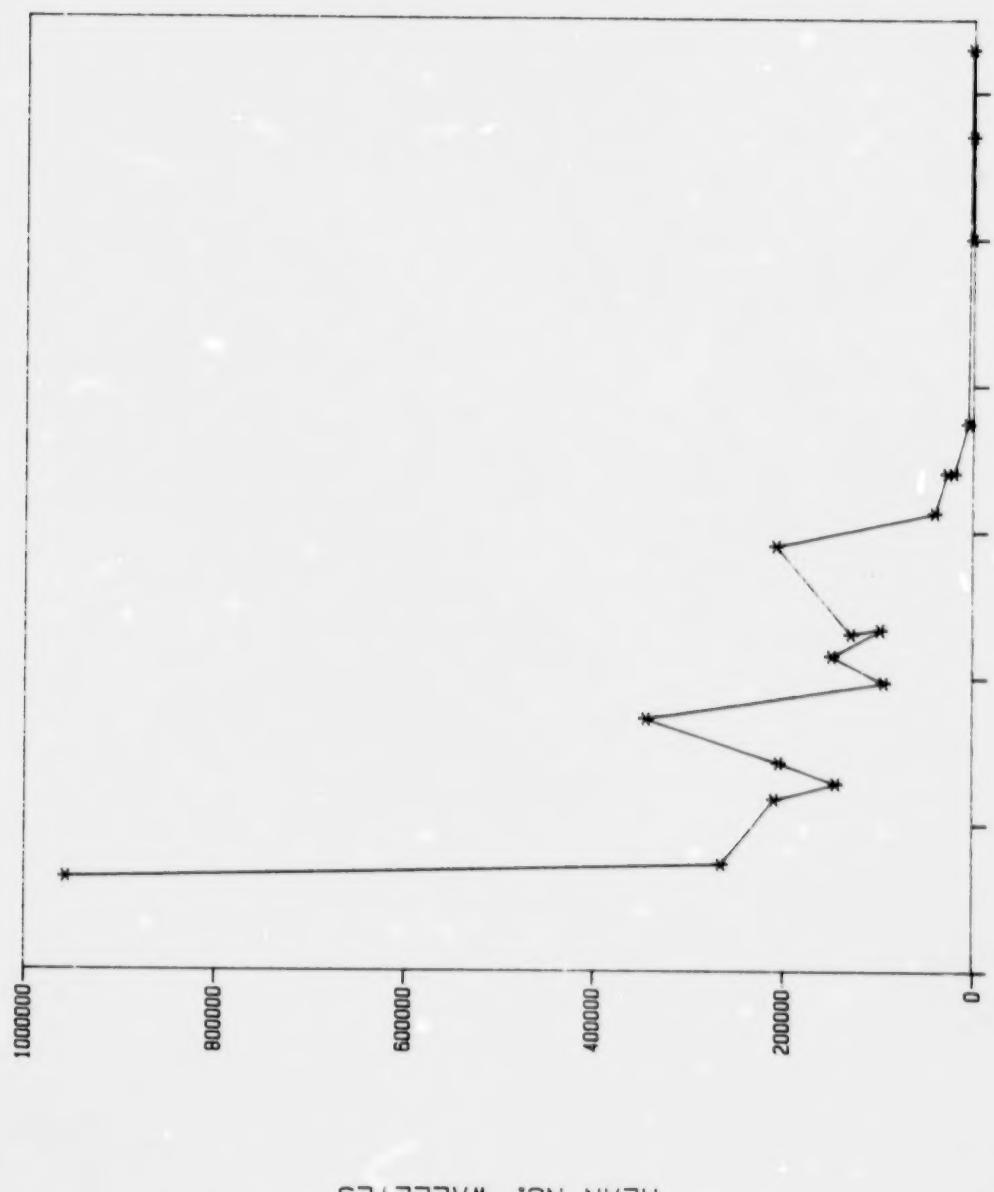


Fig. 6. Allen curve production of walleyes in Steeprock Pond.

Table 3. Age composition, mean body sizes and maturity schedules of 1987 L.Winnipegosis walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	0.26	226.00	16.00	115.00	25.00	0.00	0.00
2	77	9.96	318.57	2.18	390.78	6.56	8.82	0.00
3	288	37.26	382.94	1.28	647.90	21.31	53.17	4.32
4	261	33.76	436.56	1.51	997.59	10.97	91.74	57.89
5	99	12.81	465.67	2.94	1243.21	22.37	100.00	100.00
6	43	5.56	487.42	4.21	1399.77	41.93	90.00	93.94
7	3	0.39	522.00	18.48	1650.00	160.93	100.00	100.00

Total no. fish= 773
Total weight of all fish= 665503 grams
Overall mean length= 405.5938 S.E.= 39.38603
Overall mean weight= 920.6063 S.E.= 211.3279
No. immature males= 100 No. mature males= 206
No. immature females= 266 No. mature females= 201
Immature sex ratio= 2.66 females/male
Mature sex ratio= .9757281 females/male
Overall sex ratio= 1.526144 females/male

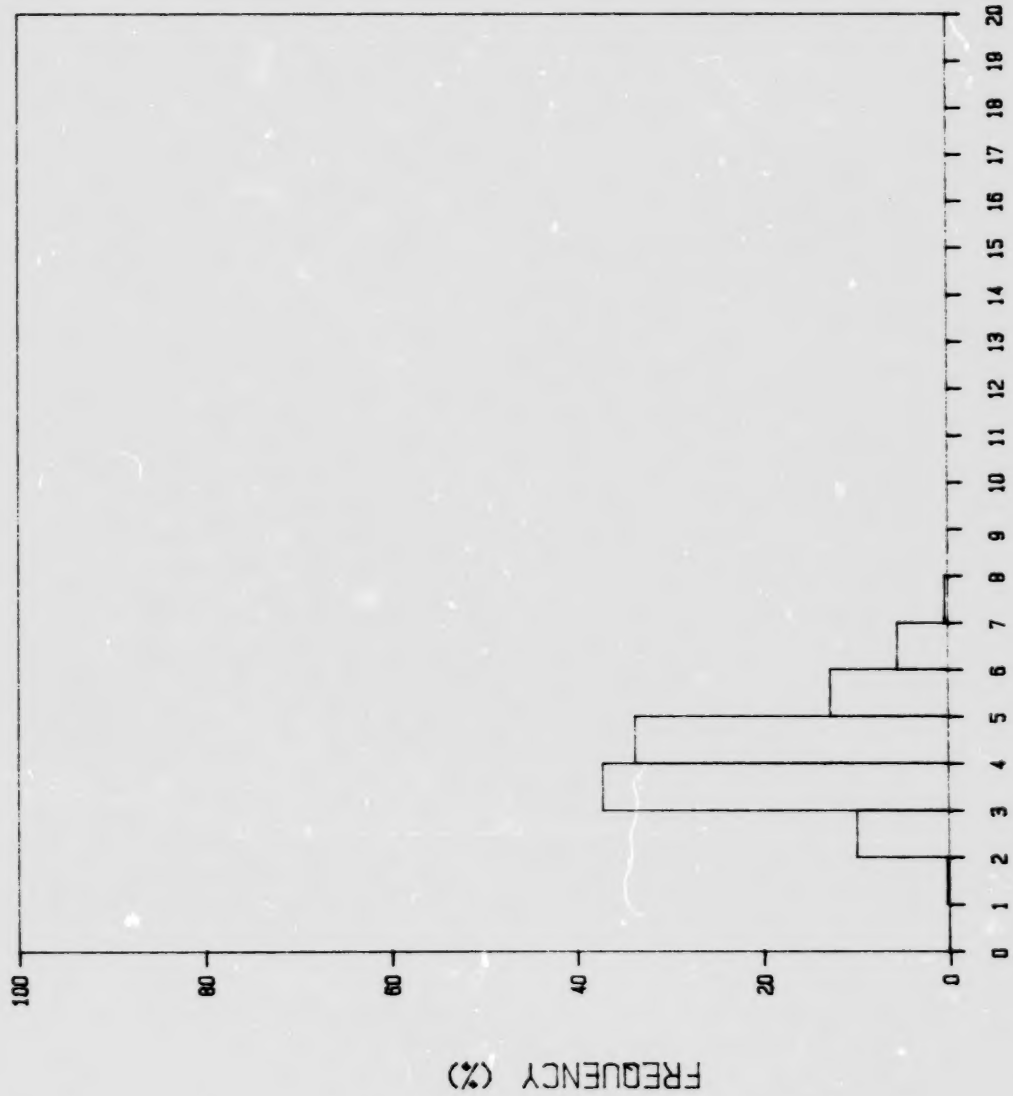


Fig. 7. Age frequencies of 1987 L. Winnipegosis walleyes.

Table 4. Age composition, mean body sizes and maturity schedules of L.Winnipegosis female walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2	0.43	226.00	15.00	115.00	25.00	0.00	0.00
2	43	9.21	320.70	3.14	390.70	8.84	0.00	0.00
3	162	34.69	382.84	1.71	661.90	37.17	0.00	4.32
4	152	32.55	441.55	2.01	1033.03	15.24	0.00	57.89
5	73	15.63	472.55	3.30	1297.53	24.87	0.00	100.00
6	33	7.07	493.42	4.75	1452.73	49.28	0.00	93.94
7	2	0.43	538.00	16.00	1810.00	30.00	0.00	100.00

Total no. fish= 467
Total weight of all fish= 427557 grams
Overall mean length= 410.7232 S.E.= 41.0622
Overall mean weight= 965.8401 S.E.= 229.4559
No. immature males= 0 No. mature males= 0
No. immature females= 266 No. mature females= 201

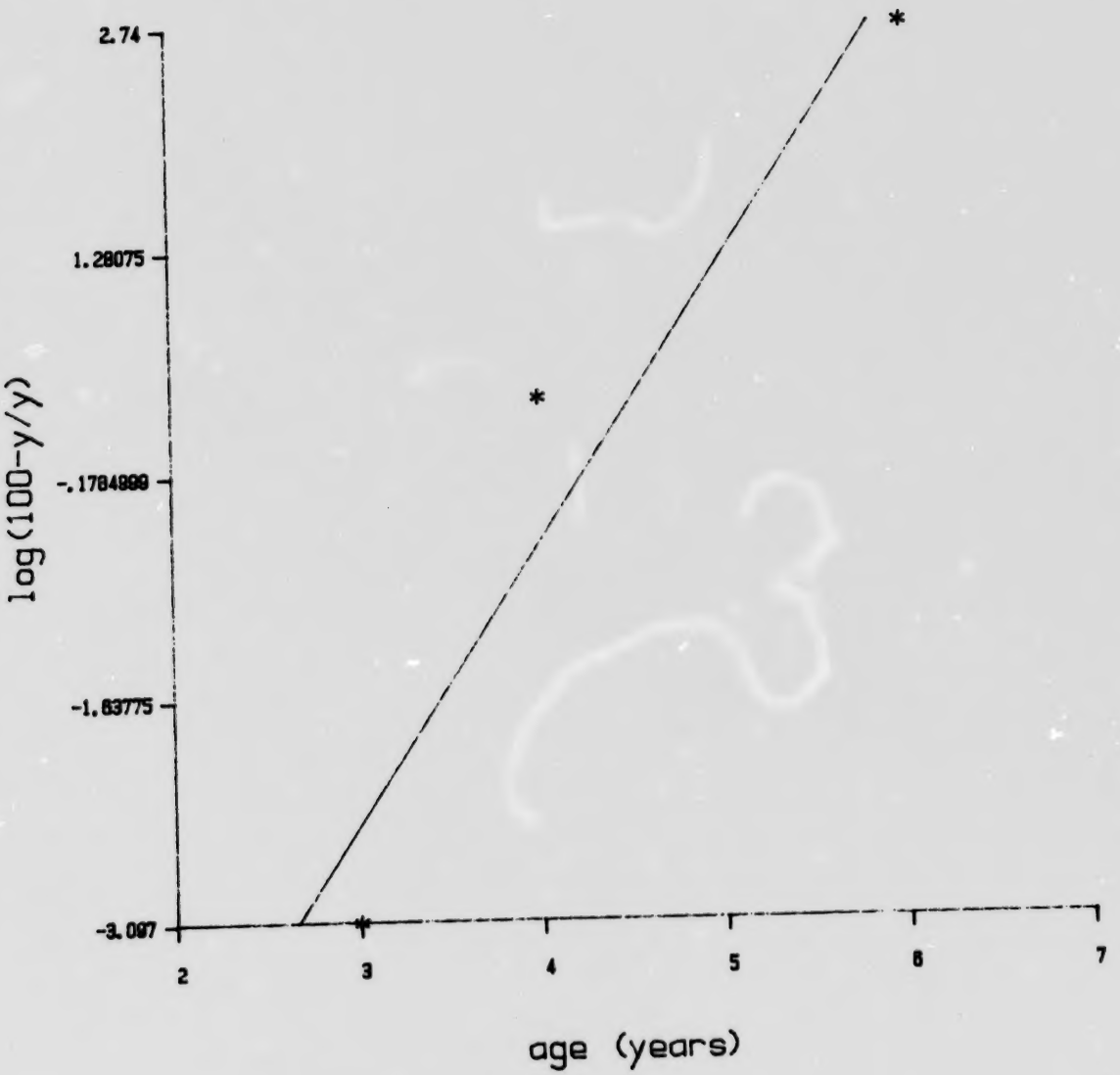


Fig. 8. Maturity curve of L. Winnipegosis walleye females.

50% of the females were mature at 4.34 years (Appendix A). The equation fitted to the maturity data of walleye males (Table 5, Fig. 9) is:

$$\log_e (100 - y/y) = -7.05 + 2.37 \text{ (age)}$$

50% of the male walleyes were mature at 2.97 years (Appendix A).

The least squares regression equation relating individual fork lengths and weights of 774 experimentally netted walleyes is:

$$\log_e \text{ weight} = -5.885 + 2.090 \log_e \text{ length}$$

correlation coefficient, r = 0.878

S.E. (slope) = 0.041

S.E. (intercept) = 0.246

The geometric mean form of this equation is:

$$\log_e \text{ weight} = -7.623 + 2.379 \log_e \text{ length}$$

Walford plots (Figs. 10-12) and Brody plots (Figs. 13-15) produced the following von Bertalanffy constants of walleye growth:

	L_∞	K	t_o
all fish	578.46	0.291	-0.715
females	553.98	0.446	0.214
males	511.71	0.413	-0.284 (Figs. 16-18, Appendix B)

To determine whether spatial patterns of walleye growth existed, data were pooled as follows:

south : gangs 1-6 (Table 6)

Duck Bay: gangs 7-8 (Table 7)

north : gangs 9-10 (Table 8)

Table 5. Age composition, mean body sizes and maturity schedules of L.Winnipegosis male walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	34	11.11	315.88	2.91	390.88	9.93	8.82	0.00
3	126	41.18	383.08	1.94	629.90	9.58	53.17	0.00
4	109	35.62	429.59	2.14	948.17	14.19	91.74	0.00
5	26	8.50	446.35	4.60	1090.69	34.69	100.00	0.00
6	10	3.27	467.60	5.83	1225.00	48.75	90.00	0.00
7	1	0.33	490.00	0.00	1330.00	0.00	100.00	0.00

Total no. fish= 306
Total weight of all fish= 237946 grams
Overall mean length= 422.0825 S.E.= 25.[illegible]
Overall mean weight= 935.7741 S.E.= 147.[illegible]
No. immature males= 100 No. mature males= [illegible]
No. immature females= 0 No. mature females= [illegible]

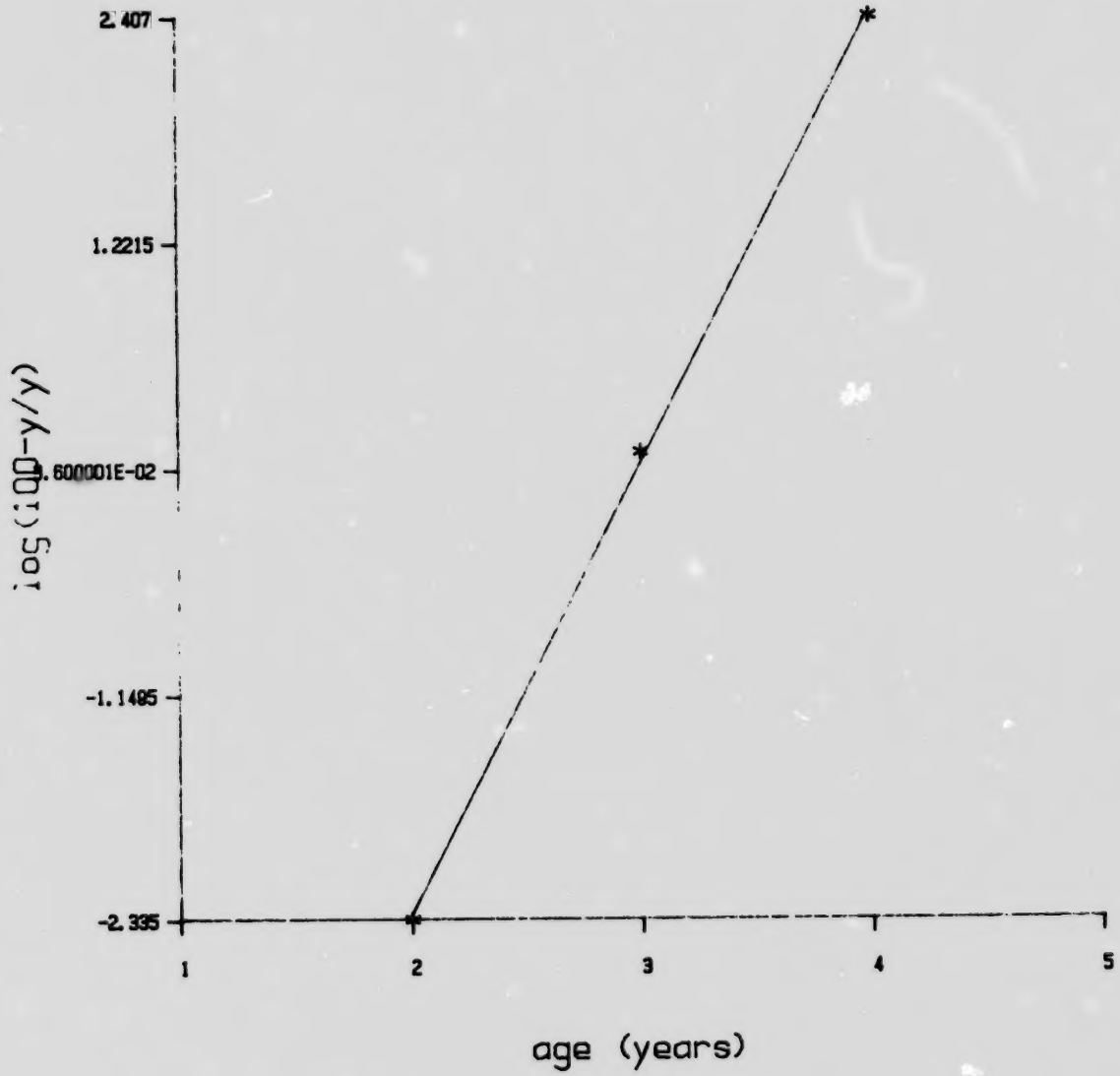


Fig. 9. Maturity curve of L. Winnipegosis walleye males.

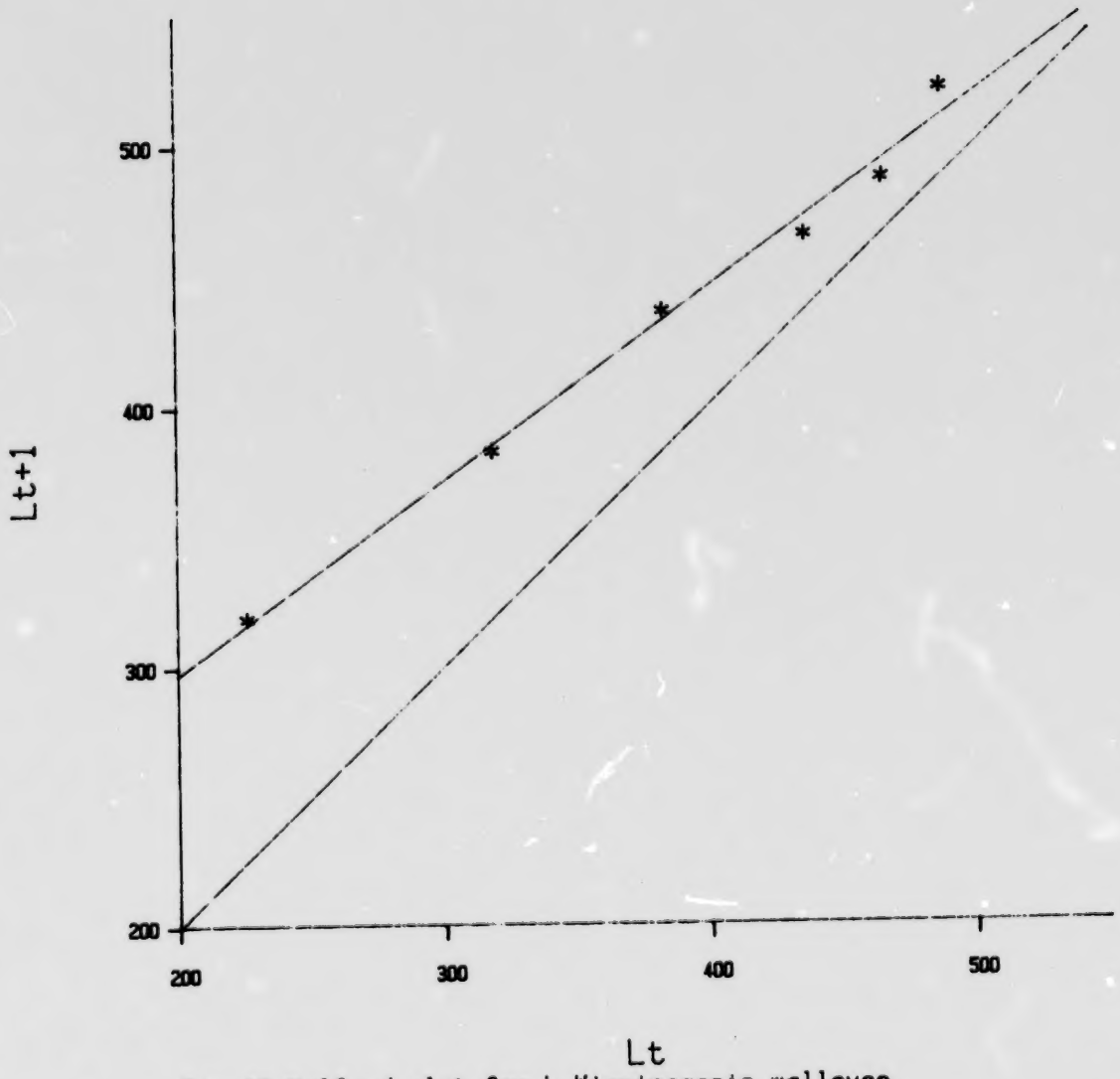


Fig. 10. Walford plot for L. Winnipegosis walleyes.

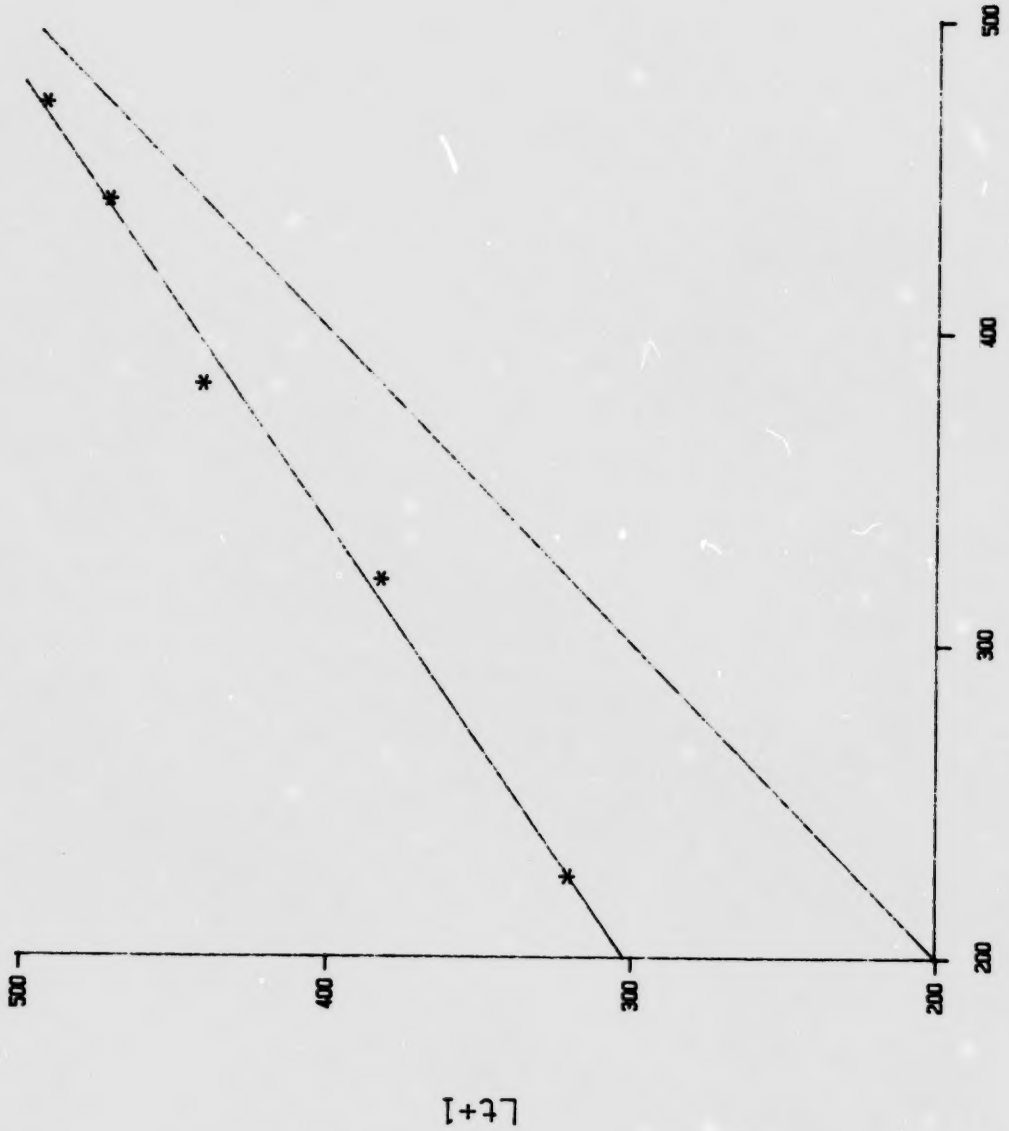


Fig. 11. Walford plot for L. Winnipegosis walleye females.

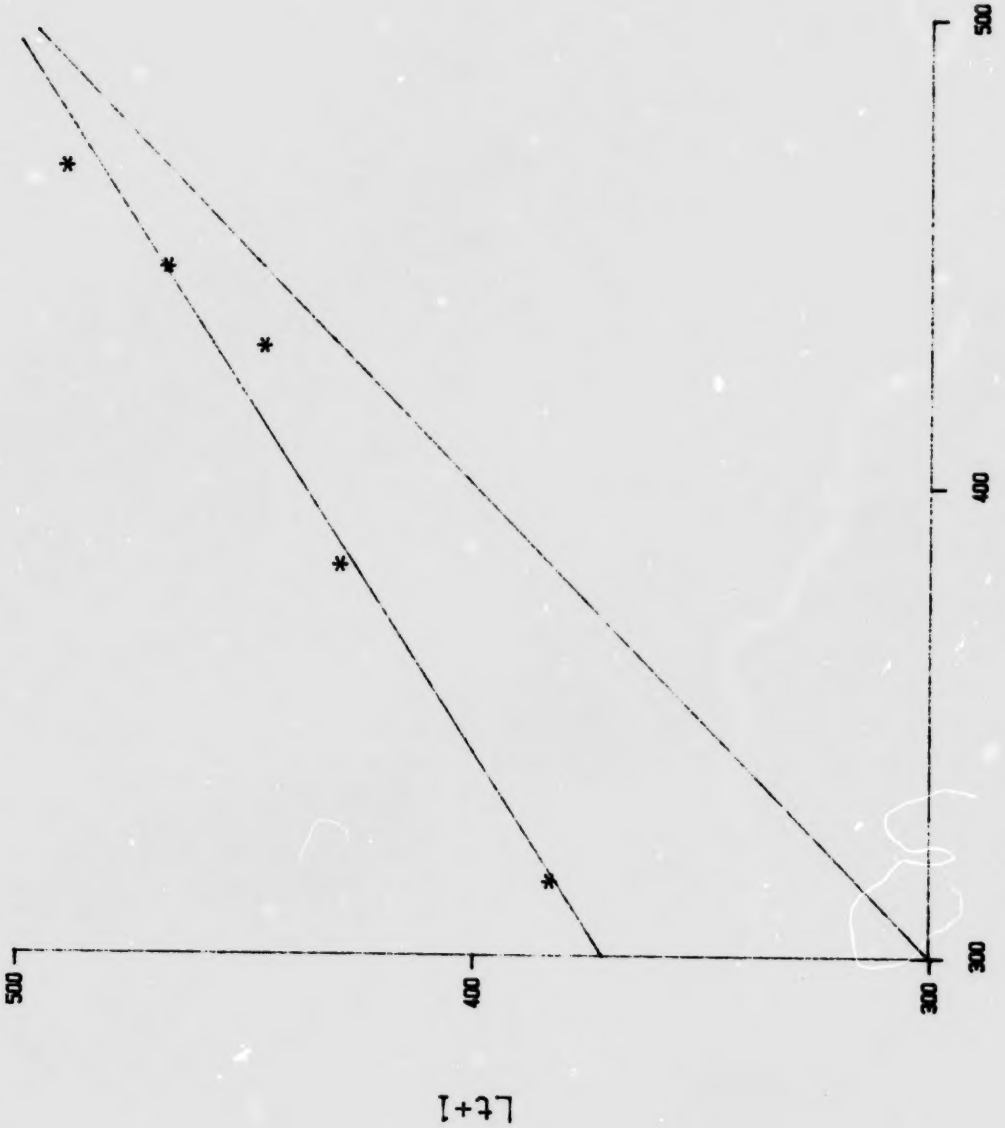


Fig. 12. Walford plot for L. Winnipegosis walleye males.

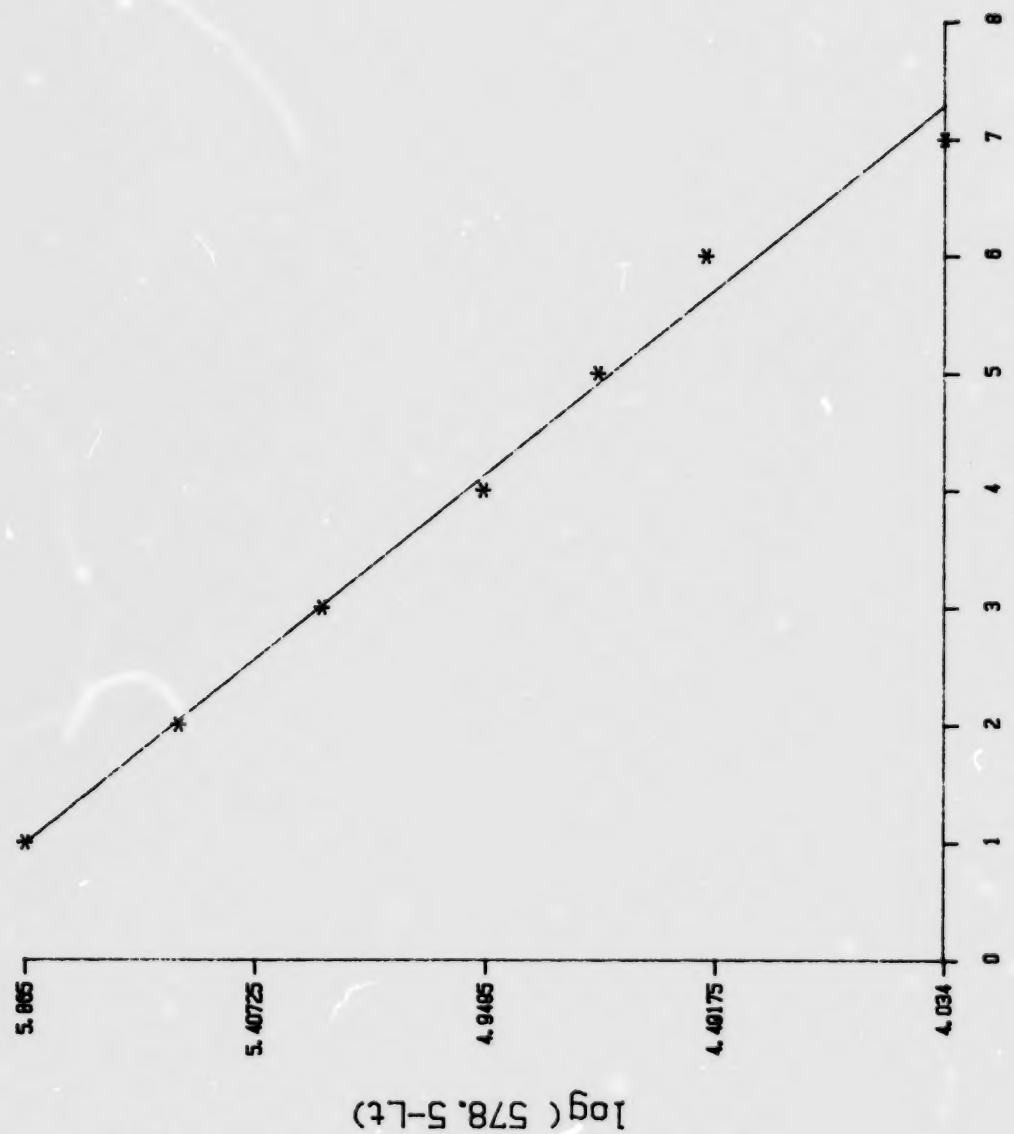


Fig. 13. Brody plot for L. Winnipegosis walleyes.

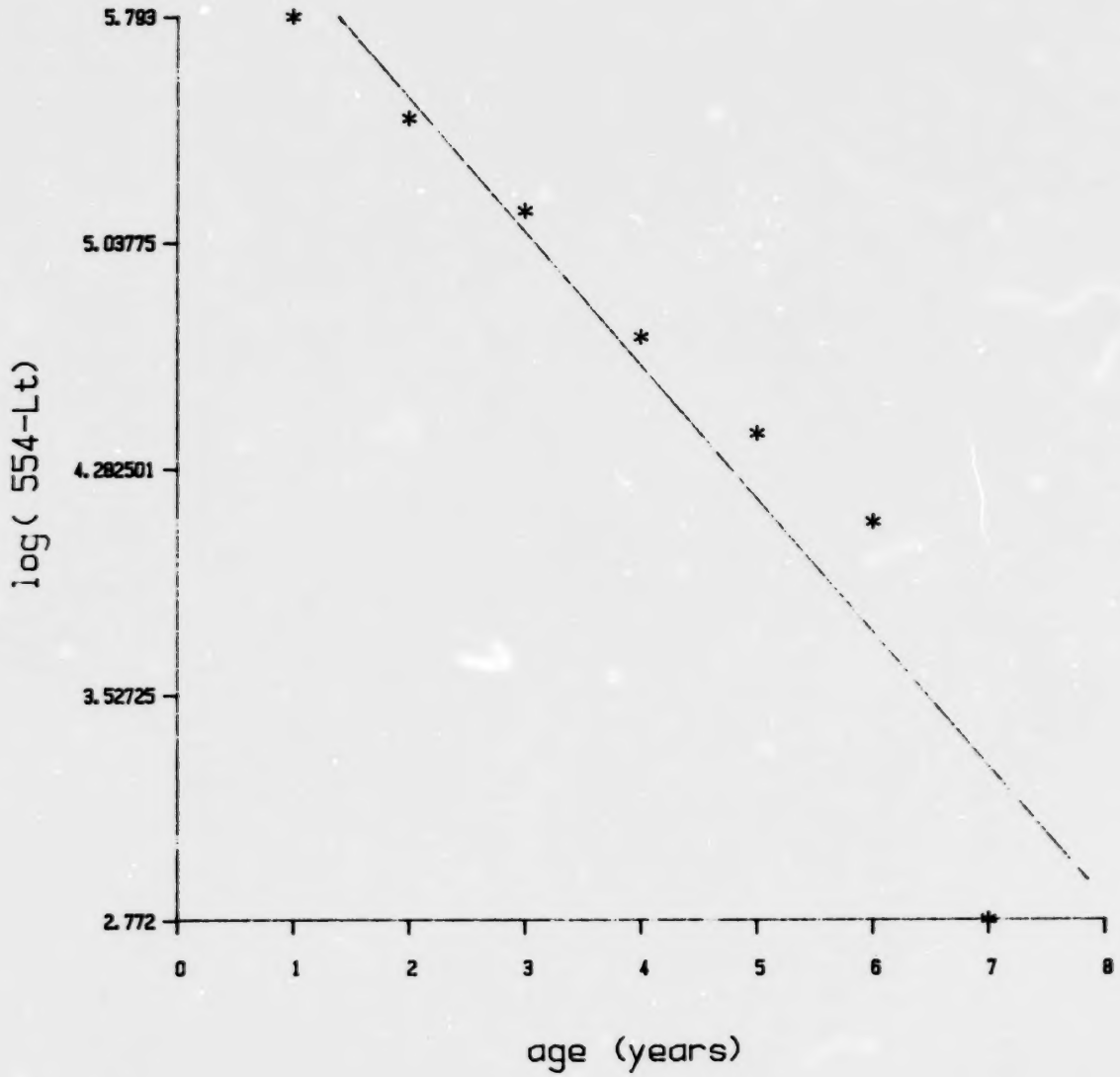


Fig. 14. Brody plot for L. Winnipegosis female walleyes.

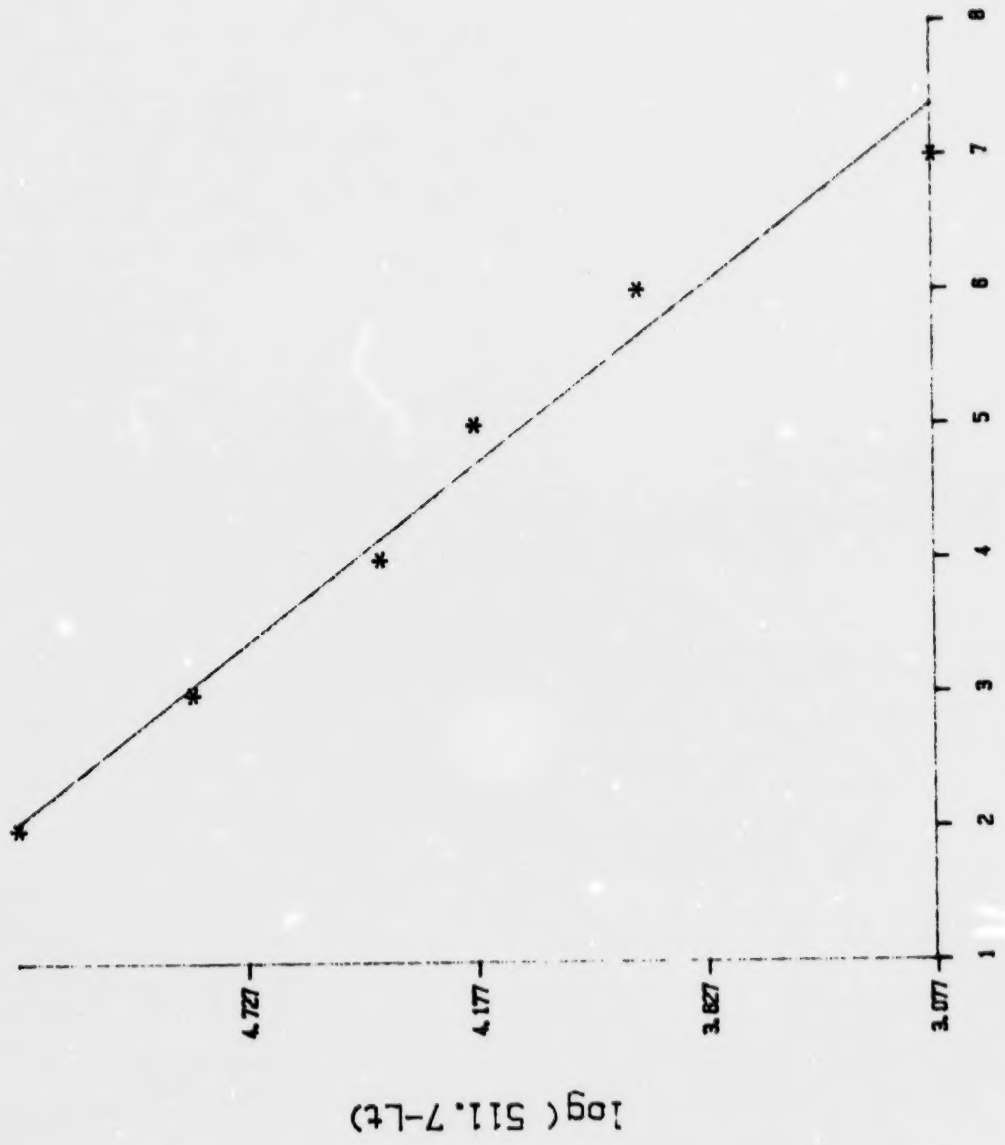


Fig. 15. Brody plot for L. Winnipegosis male walleyes.

Table 6. Age composition, mean body sizes and maturity schedules of L.Winnipegosis walleyes (south).

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.81	210.00	0.00	90.00	0.00	0.00	0.00
2	1	0.81	312.00	0.00	380.00	0.00	0.00	0.00
3	52	42.28	380.27	2.81	601.15	12.79	37.50	7.14
4	43	34.96	420.77	5.41	874.42	33.56	82.35	57.69
5	17	13.82	457.47	8.55	1144.71	59.63	100.00	100.00
6	8	6.50	487.38	8.43	1381.25	75.91	100.00	100.00
7	1	0.81	554.00	0.00	1840.00	0.00	0.00	100.00

Total no. fish= 123
Total weight of all fish= 101680 grams
Overall mean length= 403.1261 S.E.= 4[illegible]
Overall mean weight= 901.6469 S.E.= 2[illegible]
No. immature males= 19 No. mature males= 18
No. immature females= 38 No. mature females= 28
Immature sex ratio= 2 females/male
Mature sex ratio= 1.[illegible] females/male
Overall sex ratio= 1.617021 females/male

Table 7. Age composition, mean body sizes and maturity schedules of L.Winnipegosis walleyes (Duck Bay).

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	12	3.76	336.83	4.60	431.67	14.03	0.00	0.00
3	157	49.22	387.61	1.49	670.62	38.16	53.62	5.68
4	68	21.32	441.12	3.00	1007.50	21.68	85.19	82.93
5	48	15.05	467.42	4.29	1244.54	31.97	100.00	100.00
6	33	10.34	487.15	4.67	1393.94	45.03	87.50	92.00
7	1	0.31	490.00	0.00	1330.00	0.00	100.00	0.00

Total no. fish= 319
Total weight of all fish= 286045 grams
Overall mean length= 435.0207 S.E.= 24.97732
Overall mean weight= 1013.044 S.E.= 158.5791
No. immature males= 43 No. mature males= 82
No. immature females= 98 No. mature females= 96
Immature sex ratio= 2.27907 females/male
Mature sex ratio= 1.170732 females/male
Overall sex ratio= 1.552 females/male

Table 8. Age composition, mean body sizes and maturity schedules of L.Winnipegosis walleyes (north).

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.30	242.00	0.00	140.00	0.00	0.00	0.00
2	64	19.34	315.25	2.24	383.28	7.08	11.11	0.00
3	79	23.87	375.44	2.89	633.52	14.24	63.64	0.00
4	150	45.32	439.01	1.47	1028.40	11.94	96.92	45.88
5	34	10.27	467.29	4.35	1290.59	34.56	100.00	100.00
6	2	0.60	492.00	50.00	1570.00	570.00	100.00	100.00
7	1	0.30	522.00	0.00	1780.00	0.00	0.00	100.00

Total no. fish= 331
Total weight of all fish= 277778 grams
Overall mean length= 407.5715 S.E.= [illegible]
Overall mean weight= 975.1127 S.E.= [illegible]
No. immature males= 38 No. mature males= [illegible]
No. immature females= 130 No. mature females= 67
Immature sex ratio= 3.421053 females/male
Mature sex ratio= .5979167 females/male
Overall sex ratio= 1.470149 females/male

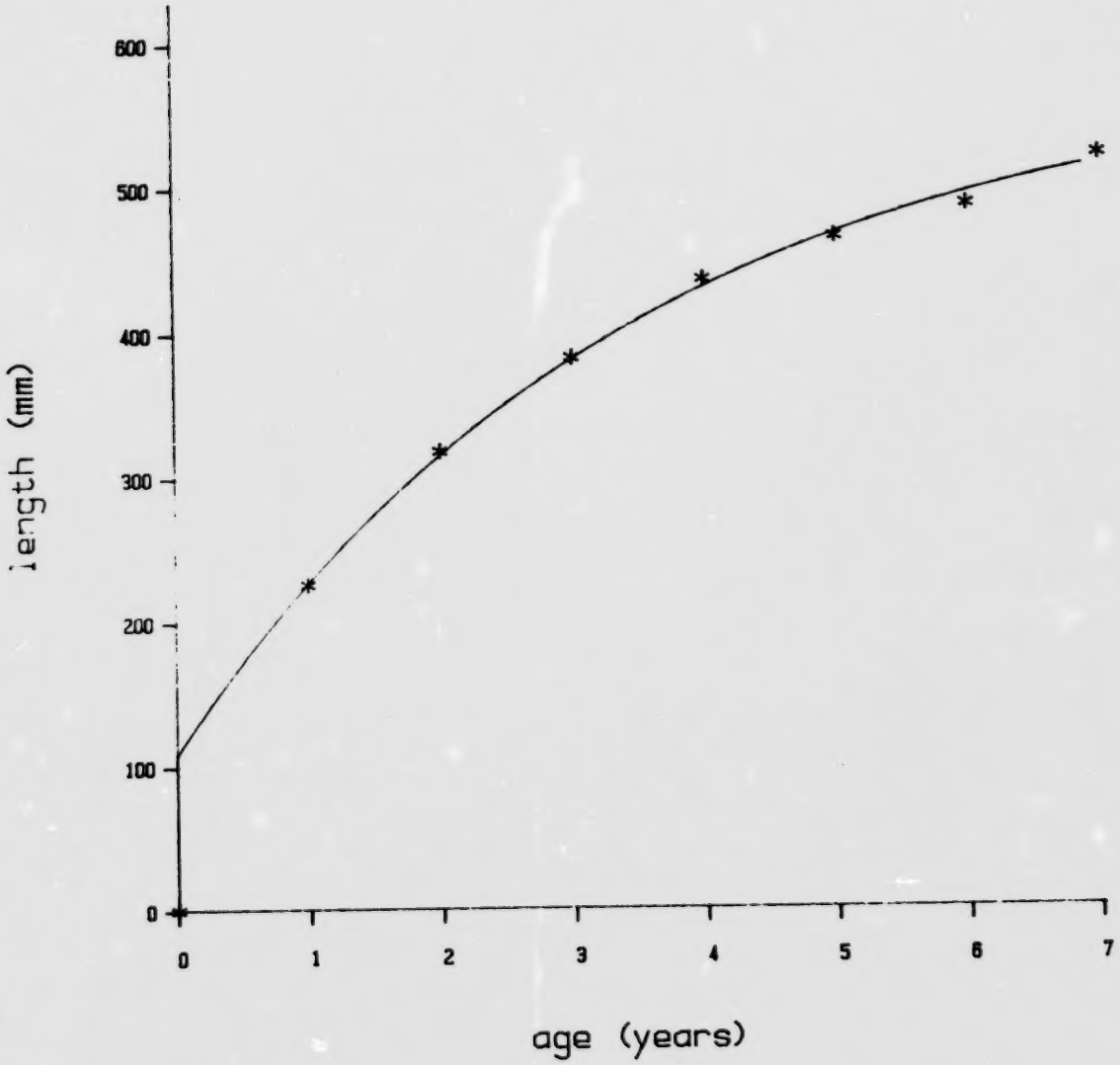


Fig. 16. Von Bertalanffy growth curve for L. Winnipegosis walleyes.

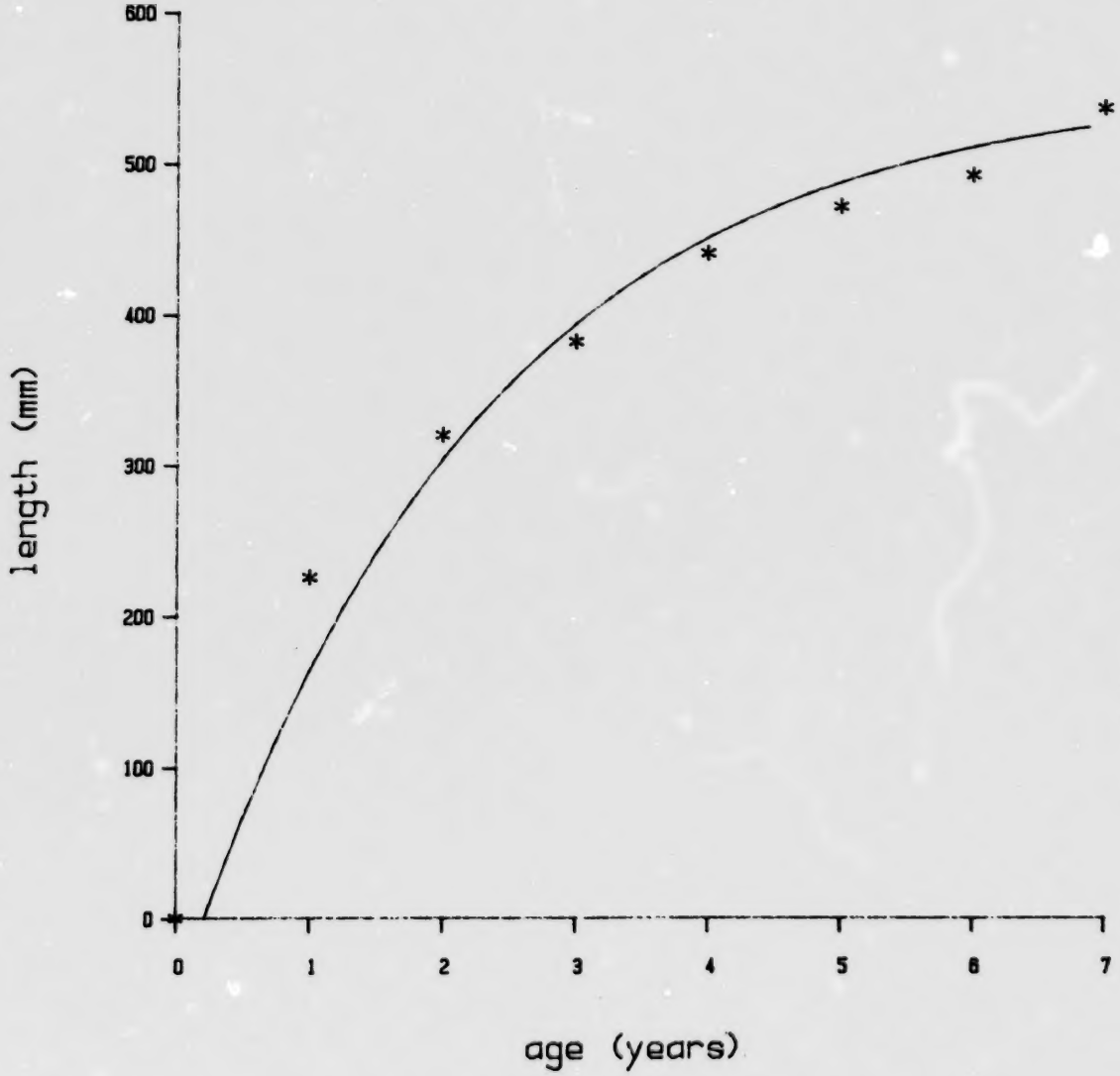


Fig. 17. Von Bertalanffy growth curve for L. Winnipegosis walleye females.

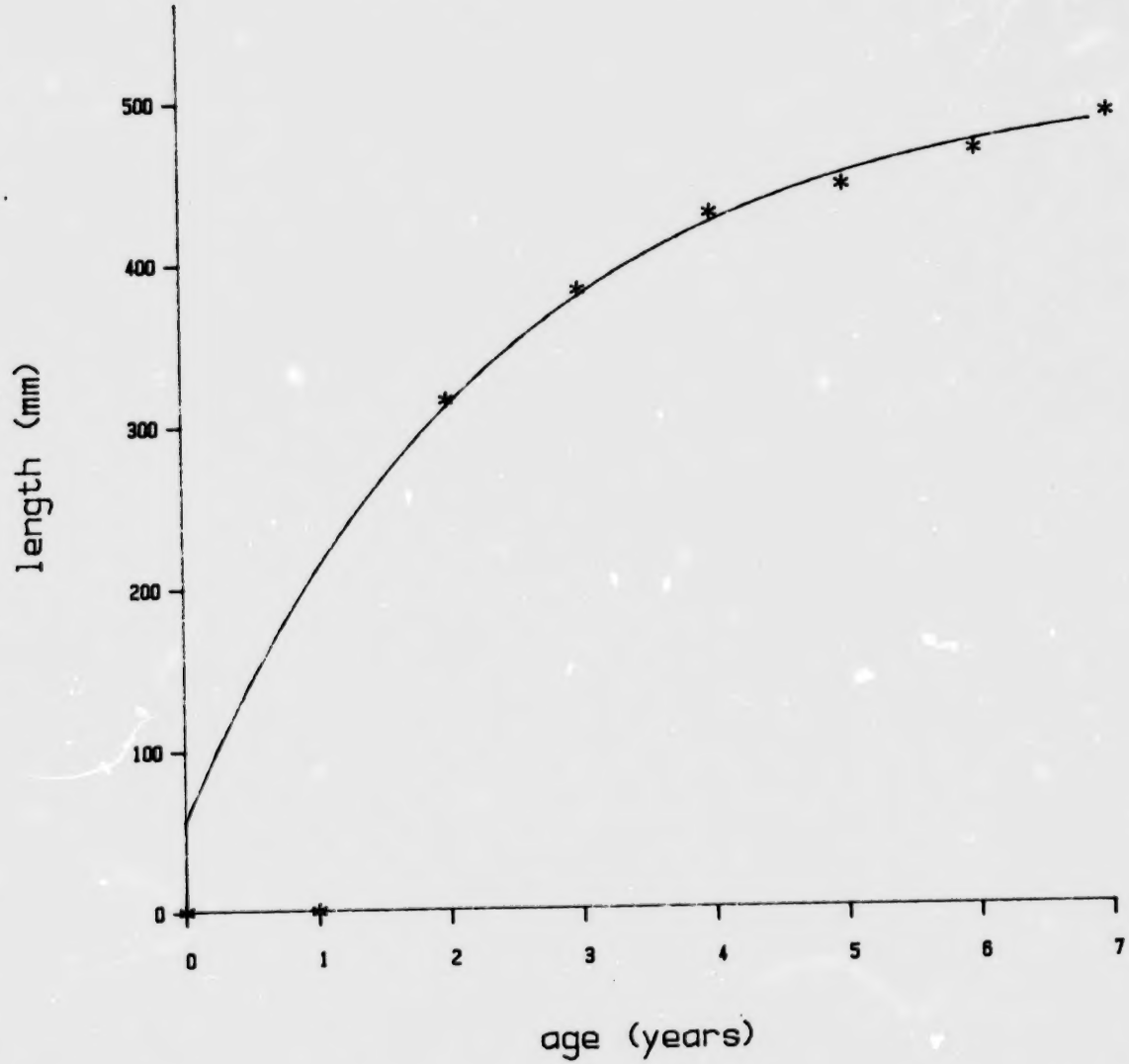


Fig. 18. Von Bertalanffy growth curve for L. Winnipegosis walleye males.

Growth analysis produced the following pattern:

	L_∞	K	t_o	$P=\log_e(L_\infty \cdot K)$
south	540.54	0.356	-0.369	5.259
Duck Bay	518.55	0.398	-0.660	5.329
north	617.01	0.227	-1.206	4.942
	(Figs. 19-21)	(Figs. 22-24)		(Figs. 25-27, Appendix B)

The Pauly statistic, P was highest for the Duck Bay walleye stock.

Recruitment of two year old walleyes increased from the south end to the north end of the lake. The 1984 cohort was relatively stronger in the central and southern portions of the lake (Fig. 28).

Three year old walleyes were dominant in the catches from smaller (3 - 3.5 inch) meshes while four year old walleyes were most frequently caught in larger (3.75 - 4.25 inch) meshes. Mean body size of walleyes increased dramatically from the 3.5 to the 4 inch mesh (Tables 9-14).

During the early part of the winter fishery, commercially caught walleyes from the north end (Dawson Bay) of the lake were dominated by the 1983 cohort (Table 15). The 1983 and 1984 cohorts co-dominated commercial catches from the central part of the lake (Table 16). Lake Winnipegosis is connected to the north end of Lake Manitoba via the West Waterhen River - Waterhen Lake - Waterhen River complex. During December 1987, commercial catches from the north end of Lake Manitoba (Crane River) and the Waterhen complex were also dominated by the 1983 cohort of walleyes (Tables 17, 18; Fig. 29). By February,

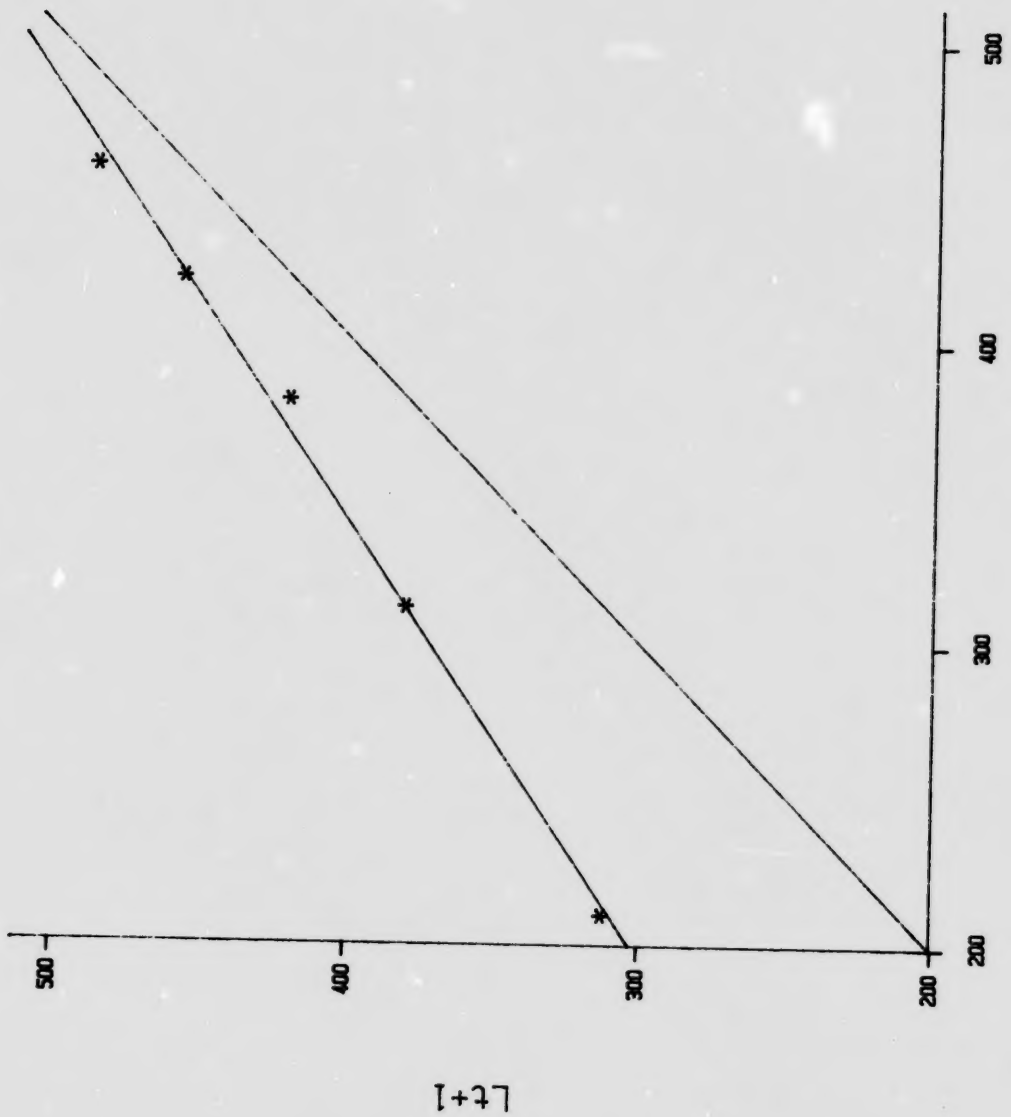


Fig. 19. Walford plot for southern walleyes.

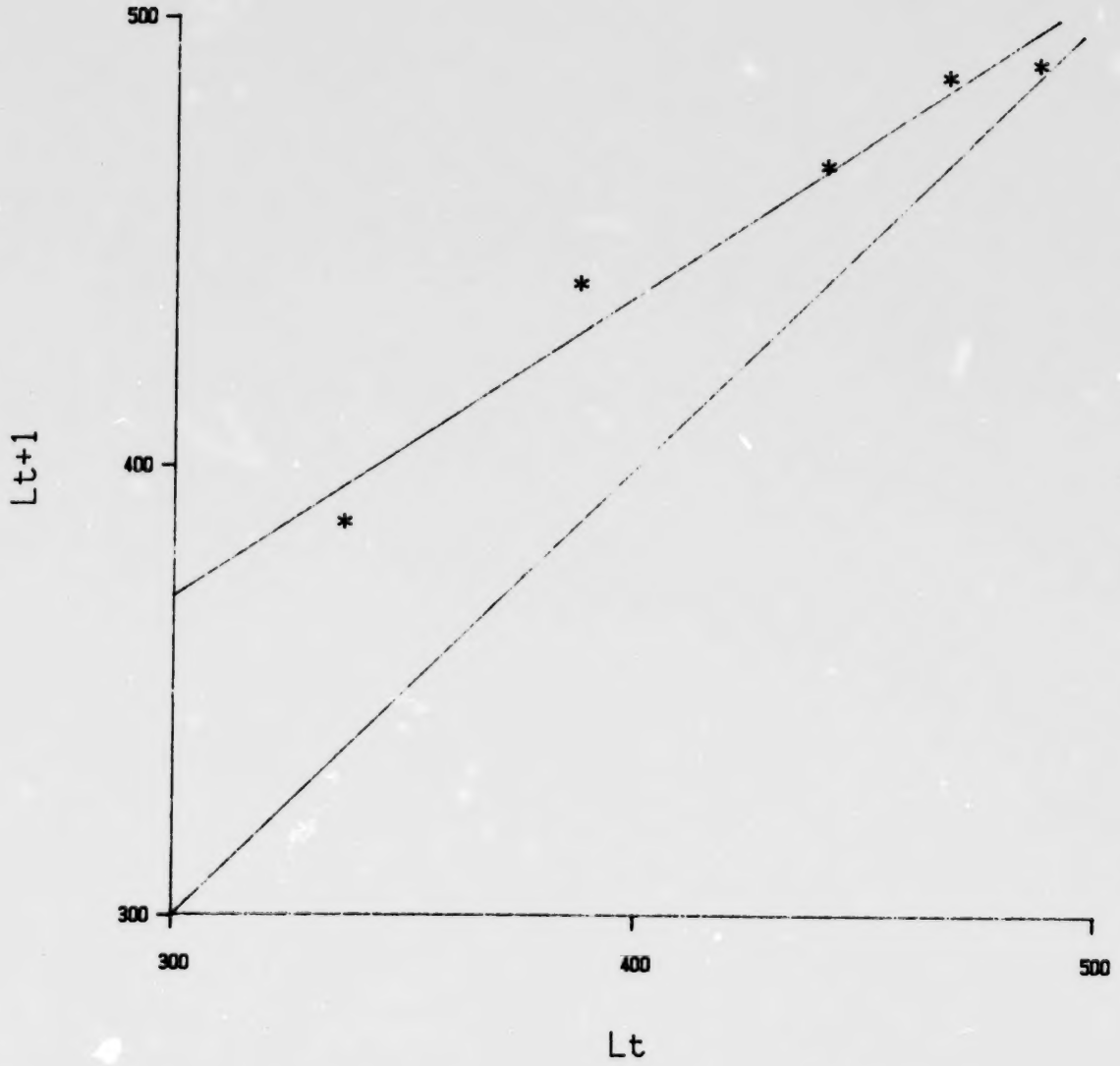


Fig. 20. Walford plot for Duck Bay walleyes.

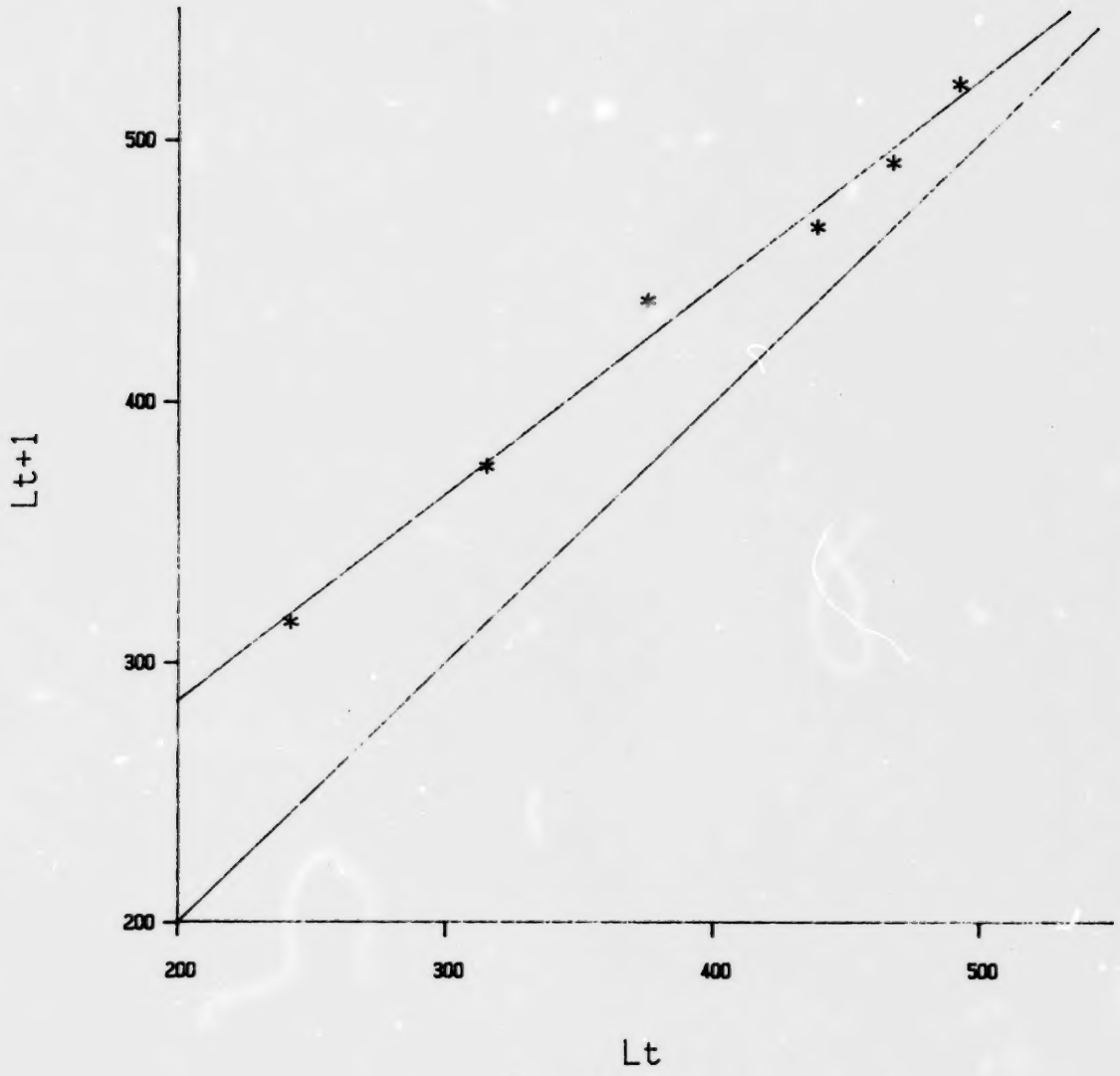


Fig. 21. Walford plot for northern walleyes.

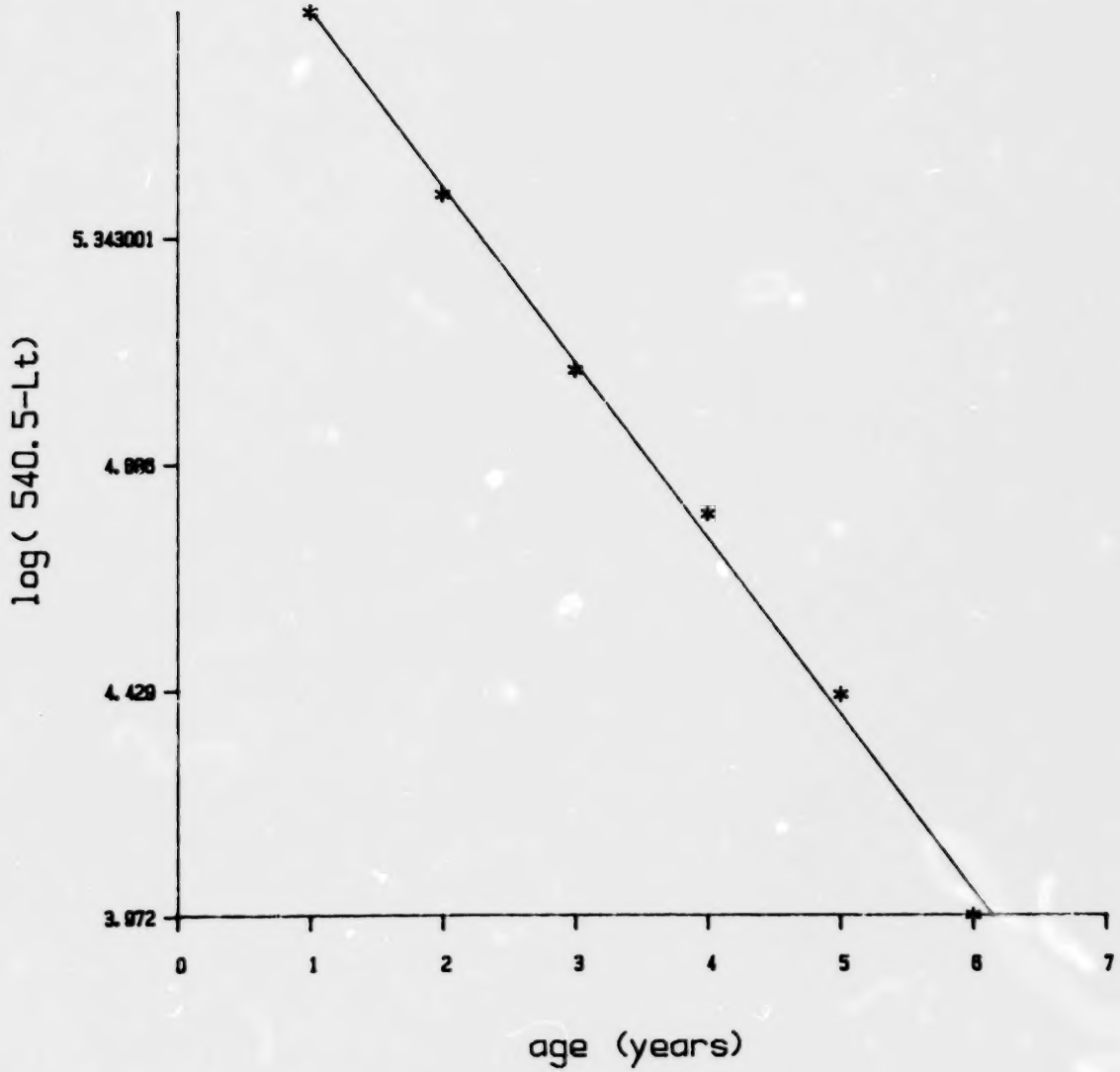


Fig. 22. Brody plot for southern walleyes.

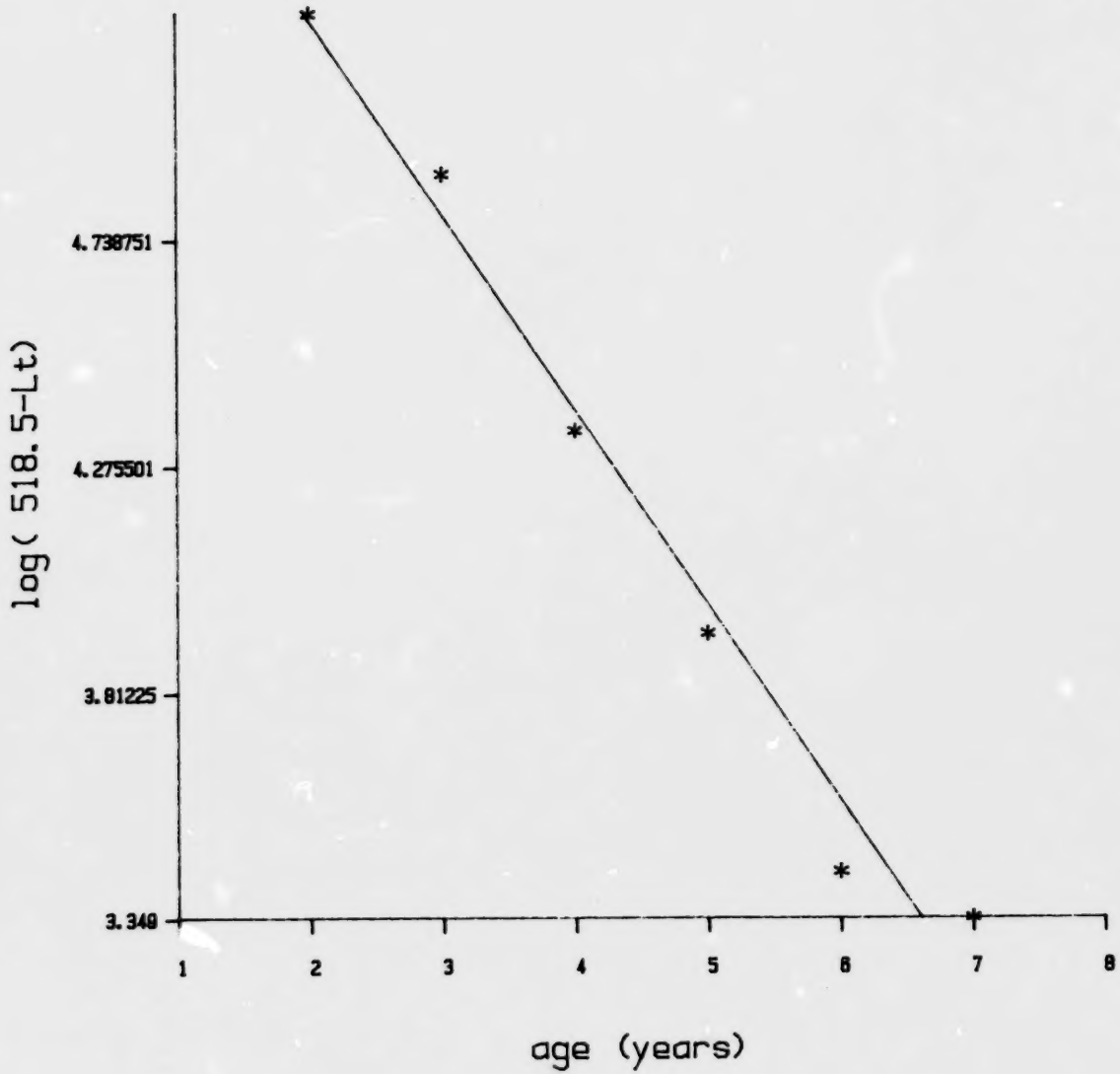


Fig. 23. Brody plot for Duck Bay walleyes.

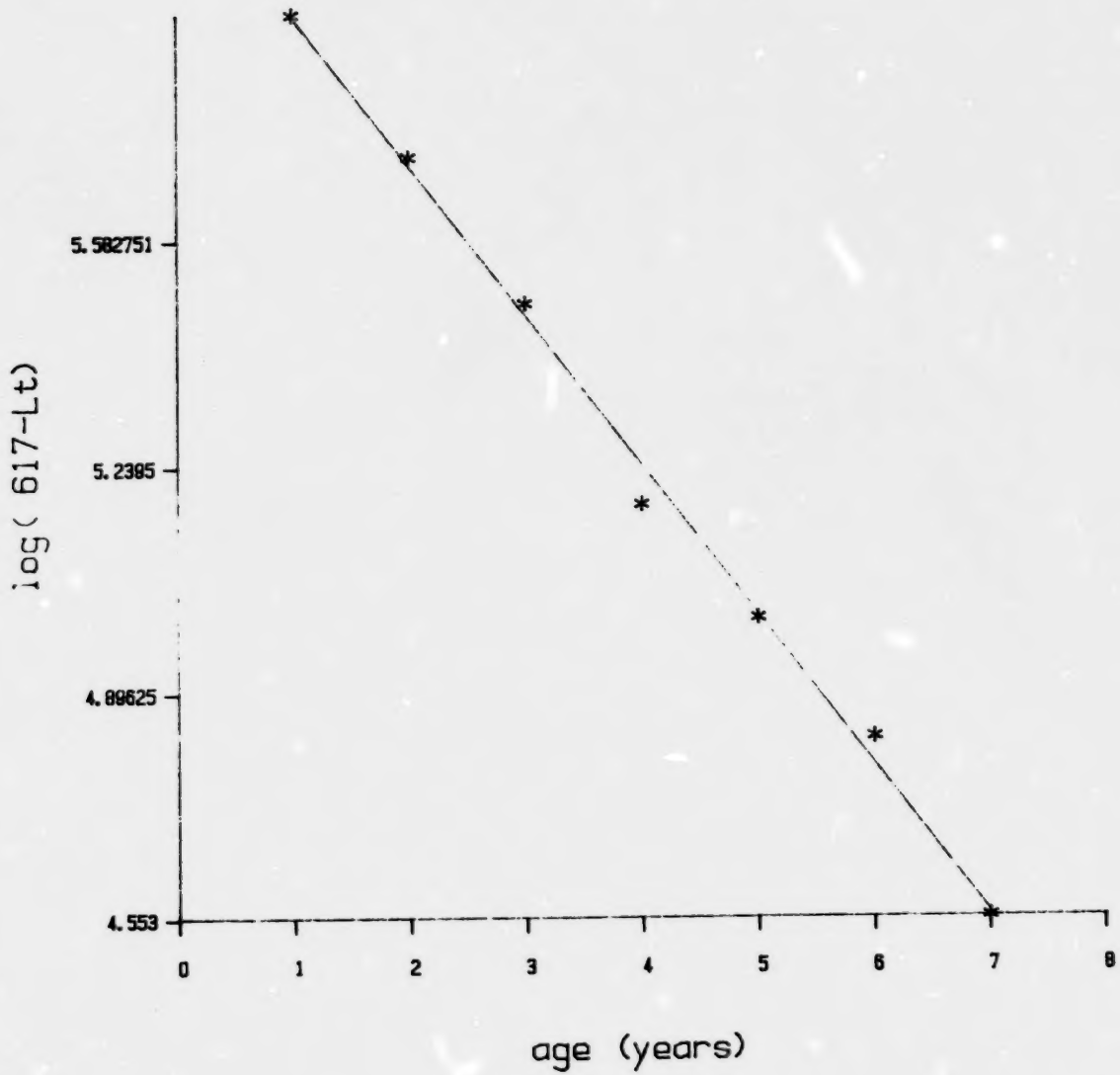


Fig. 24. Brody plot for northern walleyes.

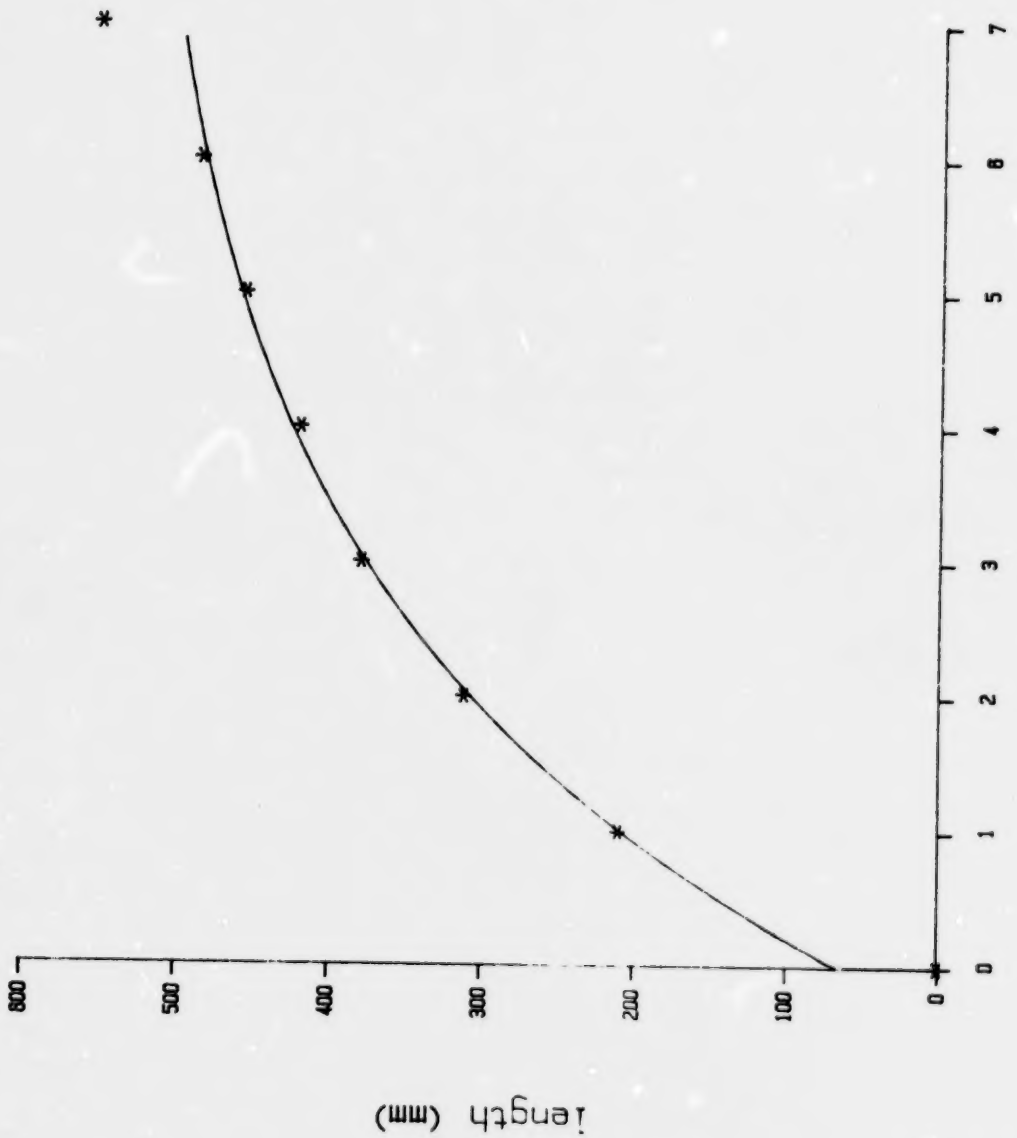


Fig. 25. Von Bertalanffy curve for southern walleyes.

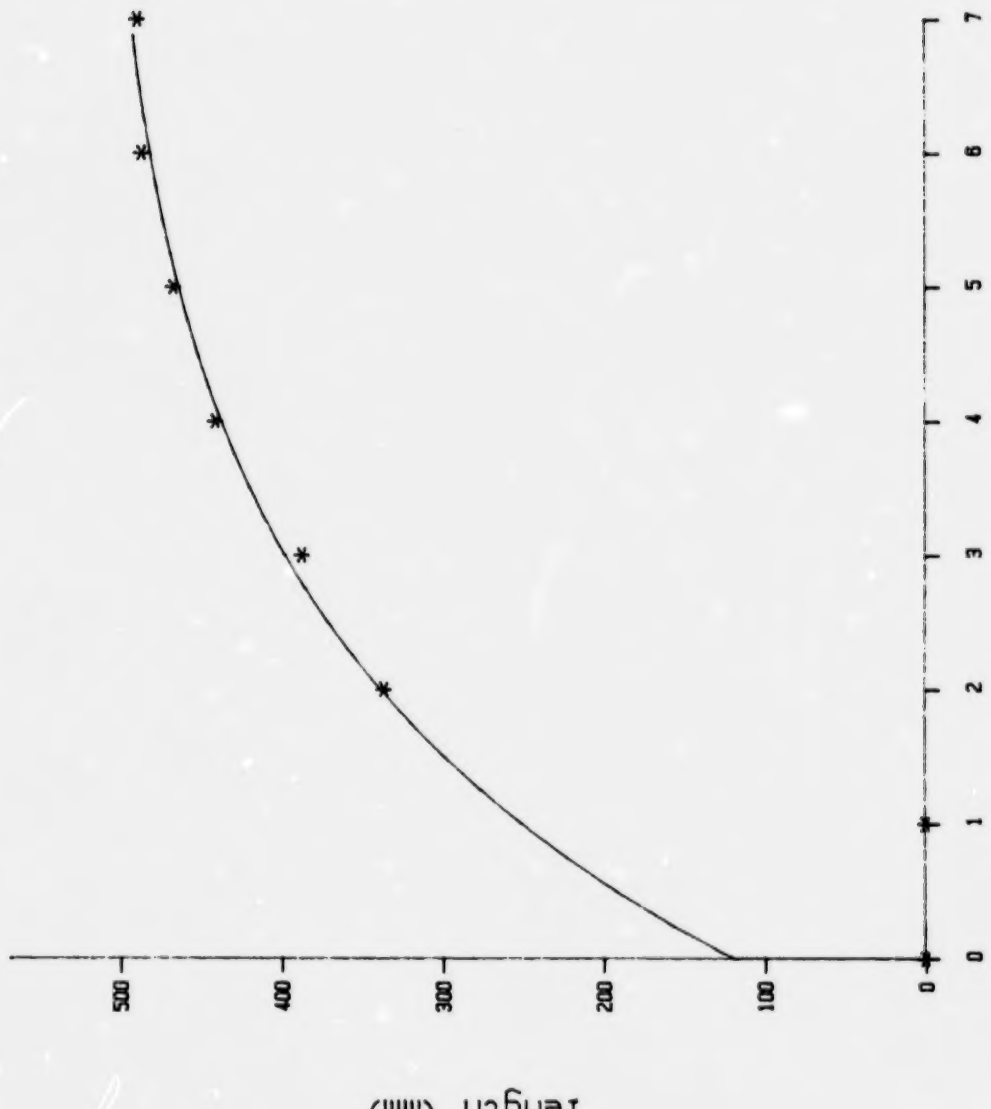


Fig. 26. Von Bertalanffy curve for Duck Bay walleyes.

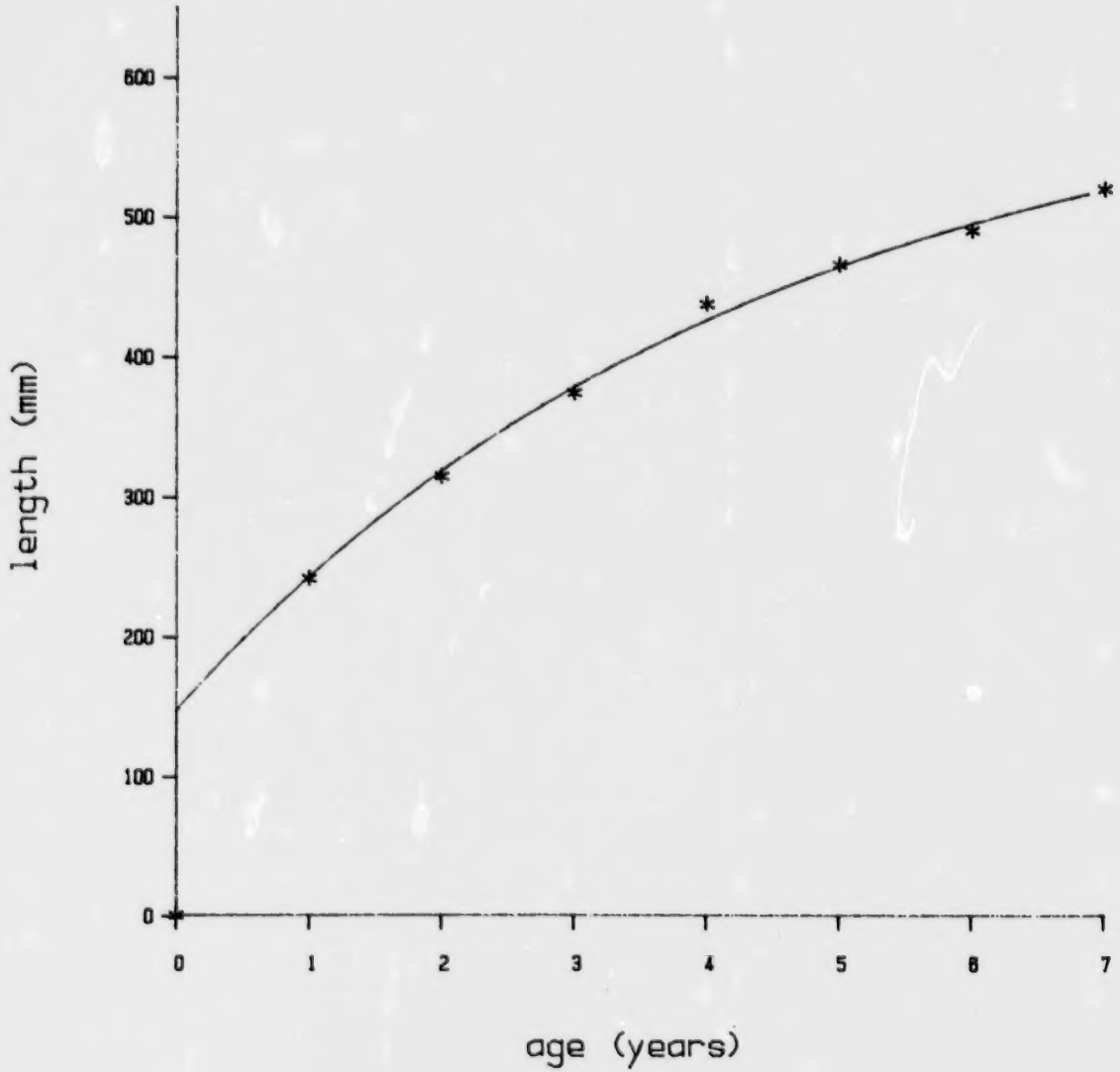


Fig. 27. Von Bertalanffy curve for northern walleyes.

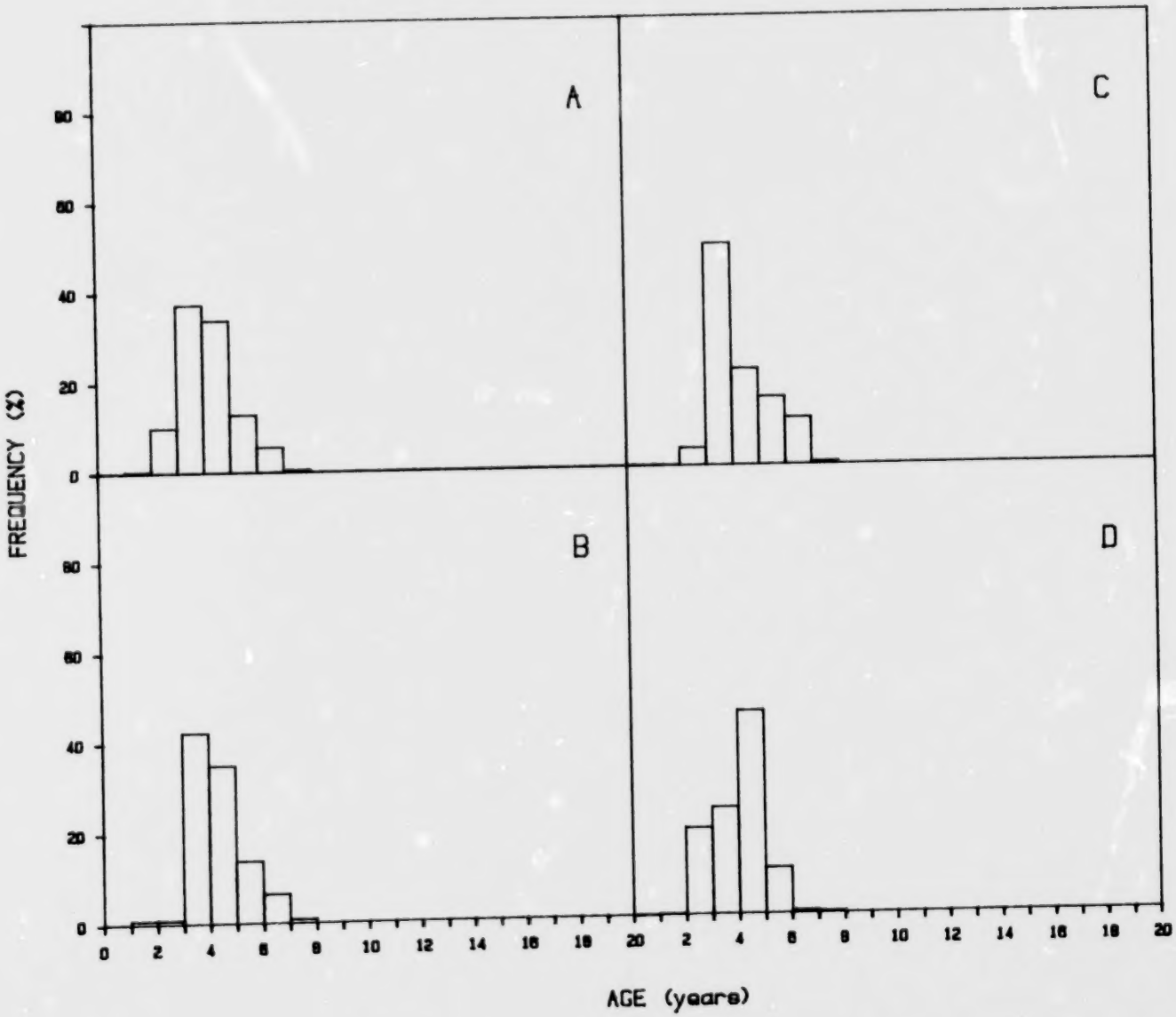


Fig. 28. Age frequencies of : A-1987 L. Winnipegosis walleyes. B-L. Winnipegosis walleyes (south). C-L. Winnipegosis walleyes (Duck Bay). D-L. Winnipegosis walleyes (north).

Table 9. Age composition, mean body sizes and maturity schedules of 3 inch L.Winnipegosis walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.42	242.00	0.00	140.00	0.00	0.00	0.00
2	49	20.68	317.14	2.97	374.29	7.75	10.00	0.00
3	101	42.62	376.73	2.40	653.73	59.45	59.57	1.85
4	66	27.85	430.18	3.57	958.18	25.32	96.43	57.89
5	13	5.49	467.54	6.76	1245.39	59.99	100.00	100.00
6	6	2.53	487.83	10.61	1378.33	89.50	100.00	100.00
7	1	0.42	522.00	0.00	1780.00	0.00	0.00	100.00

Total no. fish= 237
Total weight of all fish= 172067 grams
Overall mean length= 406.2042 S.E.= 37.85066
Overall mean weight= 932.8454 S.E.= 220.0081
No. immature males= 38 No. mature males= 61
No. immature females= 99 No. mature females= 39
Immature sex ratio= 2.605263 females/male
Mature sex ratio= .6393443 females/male
Overall sex ratio= 1.393939 females/male

Table 10. Age composition, mean body sizes and maturity schedules of 3.25 inch L.Winnipegosis walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	19	10.00	320.84	3.80	422.63	13.02	0.00	0.00
3	83	43.68	381.88	2.09	613.71	10.33	35.90	4.55
4	65	34.21	435.48	3.12	991.23	22.94	83.33	51.22
5	12	6.32	455.92	14.32	1179.17	98.84	100.00	100.00
6	11	5.79	485.64	11.18	1413.64	117.68	66.67	75.00

Total no. fish= 190
Total weight of all fish= 153098 grams
Overall mean length= 415.9503 S.E.= 248.2163
Overall mean weight= 924.0752 S.E.= 662.6228
No. immature males= 38 No. mature males= 38
No. immature females= 75 No. mature females= 39
Immature sex ratio= 1.973684 females/male
Mature sex ratio= 1.026316 females/male
Overall sex ratio= 1.5 females/male

Table 11. Age composition, mean body sizes and maturity schedules of 3.5 inch L.Winnipegosis walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.56	210.00	0.00	90.00	0.00	0.00	0.00
2	9	5.08	321.56	4.93	413.33	14.53	16.67	0.00
3	91	51.41	388.68	1.98	658.90	9.86	64.71	5.26
4	50	28.25	435.46	3.30	991.00	26.41	90.91	57.14
5	21	11.86	460.00	5.84	1205.24	35.73	100.00	100.00
6	5	2.82	476.80	7.47	1268.00	87.77	100.00	100.00

Total no. fish= 177
Total weight of all fish= 144880 grams
Overall mean length= 382.0828 S.E.= 267.6136
Overall mean weight= 771.0788 S.E.= 686.5172
No. immature males= 19 No. mature males= 49
No. immature females= 70 No. mature females= 39
Immature sex ratio= 3.684211 females/male
Mature sex ratio= .7959184 females/male
Overall sex ratio= 1.602941 females/male

Table 12. Age composition, mean body sizes and maturity schedules of 3.75 inch L.Winnipegosis walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	11	21.15	392.00	4.92	722.73	24.87	50.00	20.00
4	25	48.08	441.04	4.36	1013.20	28.11	100.00	69.23
5	13	25.00	464.15	7.29	1239.23	72.09	100.00	100.00
6	3	5.77	478.00	11.02	1293.33	93.33	0.00	100.00

Total no. fish= 52
Total weight of all fish= 53270 grams
Overall mean length= 443.7985 S.E.= 502.3867
Overall mean weight= 1067.123 S.E.= 1221.64
No. immature males= 3 No. mature males= 20
No. immature females= 8 No. mature females= 21
Immature sex ratio= 2.666667 females/male
Mature sex ratio= 1.05 females/male
Overall sex ratio= 1.26087 females/male

Table 13. Age composition, mean body sizes and maturity schedules of 4 inch L.Winnipegosis walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	33	50.00	445.82	2.87	1046.06	19.24	84.62	75.00
5	25	37.88	471.60	5.58	1300.40	42.75	100.00	100.00
6	7	10.61	486.86	9.85	1392.86	86.43	100.00	100.00
7	1	1.52	490.00	0.00	1330.00	0.00	100.00	0.00

Total no. fish= 66
Total weight of all fish= 76780 grams
Overall mean length= 473.5689 S.E.= 564.0448
Overall mean weight= 1267.329 S.E.= 1370.329
No. immature males= 2 No. mature males= 17
No. immature females= 5 No. mature females= 42
Immature sex ratio= 2.5 females/male
Mature sex ratio= 2.470588 females/male
Overall sex ratio= 2.473684 females/male

Table 14. Age composition, mean body sizes and maturity schedules of 4.25 inch L.Winnipegosis walleyes.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	3.92	430.00	14.00	860.00	60.00	0.00	0.00
4	22	43.14	442.36	3.71	1059.09	29.17	100.00	41.67
5	15	29.41	471.20	5.03	1253.87	43.47	100.00	100.00
6	11	21.57	496.73	8.06	1490.91	78.33	100.00	100.00
7	1	1.96	554.00	0.00	1840.00	0.00	0.00	100.00

Total no. fish= 51
Total weight of all fish= 60228 grams
Overall mean length= 478.8582 S.E.= 486.0335
Overall mean weight= 1300.773 S.E.= 1215.317
No. immature males= 0 No. mature males= 21
No. immature females= 9 No. mature females= 21
Immature sex ratio= 1.701412E+38 females/male
Mature sex ratio= 1 females/male
Overall sex ratio= 1.428572 females/male

Table 15. Age composition and age specific mean body sizes of Dawson Bay commercial walleyes,1987

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
0	0	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00
3	6	4.35	398.67	7.28	498.33	163.70
4	113	81.88	437.44	2.35	288.14	44.05
5	10	7.25	464.40	13.23	0.00	0.00
6	4	2.90	443.00	16.52	205.00	205.00
7	2	1.45	485.00	23.00	0.00	0.00
8	2	1.45	525.00	17.00	0.00	0.00
9	1	0.72	564.00	0.00	0.00	0.00
	138					

Table 16. Age composition and age specific mean body sizes of Duck Bay commercial walleyes,1987

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
0	0	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00
3	62	44.60	404.76	2.17	775.16	13.07
4	45	32.37	447.62	3.87	1087.89	32.47
5	17	12.23	463.47	6.67	1250.59	65.78
6	12	8.63	485.08	6.52	1440.83	67.58
7	3	2.16	431.33	22.04	1013.33	177.04
	139					

Table 17. Age composition and age specific mean body sizes of Crane R. commercial walleye,Dec.87

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
0	0	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00
3	3	6.25	350.33	21.54	513.33	97.70
4	27	56.25	382.81	3.39	624.07	14.68
5	17	35.42	404.71	6.71	732.94	36.69
6	1	2.08	428.00	0.00	880.00	0.00
	48					

Table 18. Age composition and age specific mean body sizes of Waterhen commercial walleye, Dec.87

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
0	0	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00
3	3	1.50	403.33	31.12	773.33	236.81
4	102	51.00	398.30	1.95	703.73	10.85
5	56	28.00	409.04	2.50	740.71	13.22
6	28	14.00	430.43	4.48	900.36	28.86
7	7	3.50	438.00	16.25	982.86	146.38
8	1	0.50	548.00	0.00	1830.00	0.00
9	1	0.50	552.00	0.00	2000.00	0.00
10	0	0.00	0.00	0.00	0.00	0.00
11	1	0.50	595.00	0.00	2630.00	0.00
12	0	0.00	0.00	0.00	0.00	0.00
13	0	0.00	0.00	0.00	0.00	0.00
14	1	0.50	720.00	0.00	4560.00	0.00
	200					

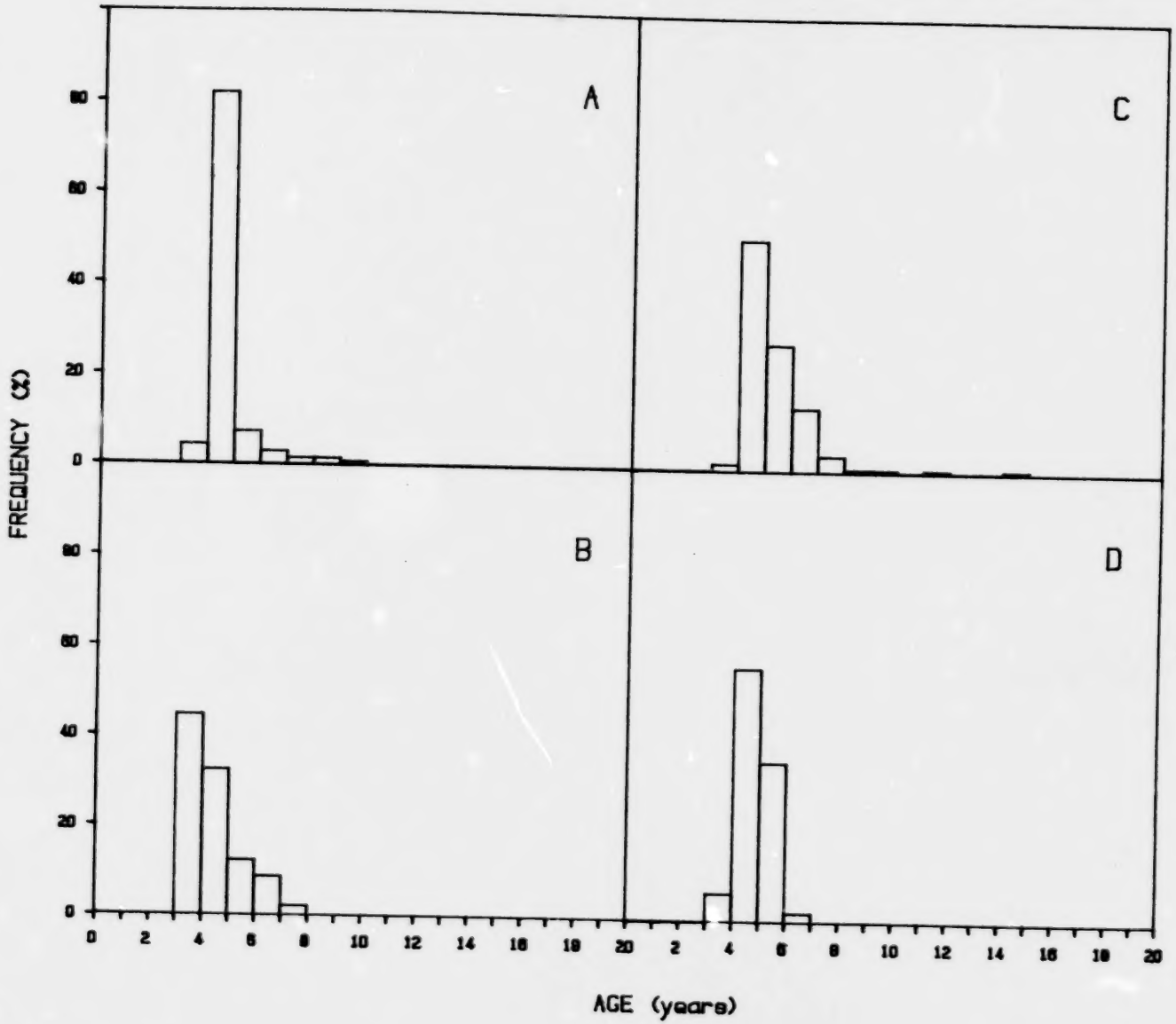


Fig. 29. Age frequencies of : A-Dawson Bay commercial walleyes B-Duck Bay commercial walleyes
C-Waterhen commercial walleye D-Crane R. commercial walleye.

1988, the fastest growing three and four year old walleyes had been removed by the fishery and smaller walleyes were recruited at Pelican Bay (Table 19). (Mean weights of Dawson Bay walleyes (Table 15) were anomalous because both round and dressed commerical catches were sampled).

The age compositions, mean body sizes and maturity schedules of other fish species caught in experimental gillnets are listed on Tables 20-27. Pike and suckers exhibited rapid growth (Fig. 30.)

Copies of old hand-drawn graphs (Figs. 31, 32) depict historical changes in fish species composition. During the 1930's walleyes (pickerel) comprised 65% of the commercial catch while suckers were relatively scarce. Currently, suckers comprise 63% of experimental catches (Fig. 33).

Suckers have dominated commercial catches since 1956. Pike yields have consistently been greater than walleye yields since 1963 (Fig. 34). Since 1970, fishing effort has increased dramatically while catch per unit of effort, CUE, has declined. Walleye CUE has remained low and constant in spite of five and six-fold increase in effort (Fig. 35). Proportions of walleyes in commercial harvests (kg.walleye/total kg.) have fluctuated erratically and have shown a long-term decline. Peak proportions are associated with full recruitment of strong cohorts (Fig. 36). The MSY parabola fitted to total annual catch and effort data from 1973 - 1986 estimates that a fishing effort = 7906 deliveries

Table 19. Age composition and age specific mean body sizes of Pelican Bay commercial walleyes,Feb.88

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.
0	0	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00
3	6	4.00	385.83	13.66	631.67	54.25
4	121	80.67	416.26	2.13	836.12	14.72
5	20	13.33	429.50	5.12	914.50	38.63
6	2	1.33	460.00	4.00	1080.00	140.00
7	1	0.67	562.00	0.00	2080.00	0.00
	150					

Table 20. Age composition, mean body sizes and maturity schedules of L.Winnipegosis pike.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.75	448.00	0.00	750.00	0.00	100.00	0.00
2	69	51.49	526.55	5.66	1164.35	39.11	100.00	98.04
3	41	30.60	519.46	5.86	1109.76	42.88	100.00	100.00
4	20	14.93	587.50	16.24	1703.50	152.74	100.00	100.00
5	3	2.24	542.67	3.71	1250.00	45.09	100.00	100.00

Total no. fish= 134
Total weight of all fish= 164410 grams
Overall mean length= 524.8362 S.E.= 22.56117
Overall mean weight= 1195.521 S.E.= 152.9424
No. immature males= 0 No. mature males= 56
No. immature females= 1 No. mature females= 77
Immature sex ratio= 1.701412E+38 females/male
Mature sex ratio= 1.375 females/male
Overall sex ratio= 1.392857 females/male

Table 21. Age composition, mean body sizes and maturity schedules of L.Winnipegosis perch.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1	1.39	176.00	0.00	90.00	0.00	0.00	100.00
4	8	11.11	171.50	12.75	86.25	28.66	0.00	100.00
5	9	12.50	244.00	12.98	243.33	30.09	0.00	100.00
6	15	20.83	268.53	4.19	312.00	13.88	0.00	100.00
7	14	19.44	279.79	4.37	335.71	14.01	100.00	100.00
8	16	22.22	280.75	2.51	327.81	8.89	100.00	100.00
9	6	8.33	281.67	6.74	335.00	23.63	0.00	100.00
10	1	1.39	270.00	0.00	300.00	0.00	0.00	100.00
11	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	2	2.78	303.00	9.00	460.00	60.00	100.00	100.00

Total no. fish= 72
Total weight of all fish= 20825 grams
Overall mean length= 252.804 S.E.= 15.80763
Overall mean weight= 276.6789 S.E.= 40.33253
No. immature males= 0 No. mature males= 3
No. immature females= 0 No. mature females= 69
Immature sex ratio= 1.701412E+38 females/male
Mature sex ratio= 23 females/male
Overall sex ratio= 23 females/male

Table 22. Age composition, mean body sizes and maturity schedules of L.Winnipegosis ciscoe.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	28.57	178.00	24.00	100.00	10.00	50.00	0.00
3	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	14.29	172.00	0.00	75.00	0.00	100.00	0.00
5	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	1	14.29	258.00	0.00	360.00	0.00	100.00	0.00
7	2	28.57	257.50	12.50	295.00	15.00	0.00	100.00
8	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	14.29	312.00	0.00	480.00	0.00	100.00	0.00

Total no. fish= 7
Total weight of all fish= 1705 grams
Overall mean length= 235.5 S.E.= 26.62799
Overall mean weight= 262 S.E.= 77.27548
No. immature males= 1 No. mature males= 4
No. immature females= 0 No. mature females= 2
Immature sex ratio= 0 females/male
Mature sex ratio= .5 females/male
Overall sex ratio= .4 females/male

Table 23. Age composition, mean body sizes and maturity schedules of L.Winnipegosis whitefish.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	5.88	299.00	9.00	400.00	20.00	50.00	0.00
4	13	38.24	316.62	5.07	425.38	25.41	16.67	42.86
5	10	29.41	348.20	16.89	606.00	70.89	100.00	75.00
6	8	23.53	372.50	6.87	797.50	59.84	50.00	100.00
7	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1	2.94	470.00	0.00	1550.00	0.00	100.00	0.00

Total no. fish= 34
Total weight of all fish= 20320 grams
Overall mean length= 361.2631 S.E.= 29.99224
Overall mean weight= 755.777 S.E.= 211.0332
No. immature males= 7 No. mature males= 6
No. immature females= 6 No. mature females= 15
Immature sex ratio= .8571429 females/male
Mature sex ratio= 2.5 females/male
Overall sex ratio= 1.615385 females/male

Table 24. Age composition, mean body sizes and maturity schedules of L.Winnipegosis goldeye.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	3.03	230.00	44.00	160.00	70.00	0.00	100.00
4	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	4	6.06	310.50	6.85	345.00	9.57	50.00	0.00
6	11	16.67	316.36	2.20	375.45	9.66	50.00	22.22
7	25	37.88	319.92	2.24	404.40	11.05	33.33	42.11
8	17	25.76	329.41	3.26	424.71	13.20	57.14	50.00
9	7	10.61	325.14	3.14	397.14	11.07	40.00	0.00

Total no. fish= 66
Total weight of all fish= 25940 grams
Overall mean length= 305.2231 S.E.= 15.28439
Overall mean weight= 351.1172 S.E.= 39.80295
No. immature males= 13 No. mature males= 10
No. immature females= 27 No. mature females= 16
Immature sex ratio= 2.076923 females/male
Mature sex ratio= 1.6 females/male
Overall sex ratio= 1.869565 females/male

Table 25. Age composition, mean body sizes and maturity schedules of L.Winnipegosis suckers.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	0.46	332.00	0.00	500.00	0.00	0.00	0.00
3	21	9.72	333.71	4.73	515.71	26.03	25.00	29.41
4	94	43.52	357.70	2.79	650.85	15.48	68.18	34.00
5	50	23.15	383.54	3.80	838.80	25.79	96.15	91.67
6	27	12.50	403.44	4.69	962.22	30.53	100.00	88.24
7	17	7.87	421.29	4.26	1151.18	31.62	100.00	100.00
8	4	1.85	421.50	13.07	1177.50	75.54	100.00	100.00
9	2	0.93	451.00	5.00	1295.00	115.00	0.00	100.00

Total no. fish= 216
Total weight of all fish= 167300 grams
Overall mean length= 388.0244 S.E.= 15.50288
Overall mean weight= 886.408 S.E.= 109.5454
No. immature males= 19 No. mature males= 73
No. immature females= 49 No. mature females= 75
Immature sex ratio= 2.578947 females/male
Mature sex ratio= 1.027397 females/male
Overall sex ratio= 1.347826 females/male

Table 26. Age composition, mean body sizes and maturity schedules of L.Winnipegosis sauger.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	11.11	356.00	0.00	510.00	0.00	0.00	100.00
5	2	22.22	357.50	2.50	475.00	25.00	0.00	100.00
6	4	44.44	381.75	10.44	625.00	39.69	0.00	100.00
7	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1	11.11	448.00	0.00	940.00	0.00	0.00	100.00
10	1	11.11	468.00	0.00	1120.00	0.00	0.00	100.00

Total no. fish= 9
Total weight of all fish= 6020 grams
Overall mean length= 402.25 S.E.= 23.42862
Overall mean weight= 734 S.E.= 126.6037
No. immature males= 0 No. mature males= 0
No. immature females= 0 No. mature females= 9
Immature sex ratio= 1.701412E+38 females/male
Mature sex ratio= 1.701412E+38 females/male
Overall sex ratio= 1.701412E+38 females/male

Table 27. Age composition, mean body sizes and maturity schedules of L.Winnipegosis carp.

Age (years)	No. fish	Frequency (%)	Mean length (mm)	1 S.E.	Mean weight (gm)	1 S.E.	Frequency of mature fish	
							Male	Female
0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1	11.11	336.00	0.00	560.00	0.00	0.00	0.00
5	2	22.22	341.00	3.00	600.00	0.00	100.00	0.00
6	4	44.44	381.50	8.22	947.50	69.69	100.00	100.00
7	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	1	11.11	396.00	0.00	1060.00	0.00	0.00	100.00
9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1	11.11	468.00	0.00	1120.00	0.00	0.00	100.00

Total no. fish= 9
Total weight of all fish= 7730 grams
Overall mean length= 384.5 S.E.= 23.83066
Overall mean weight= 857.5 S.E.= 116.7958
No. immature males= 0 No. mature males= 2
No. immature females= 2 No. mature females= 5
Immature sex ratio= 1.701412E+38 females/male
Mature sex ratio= 2.5 females/male
Overall sex ratio= 3.5 females/male

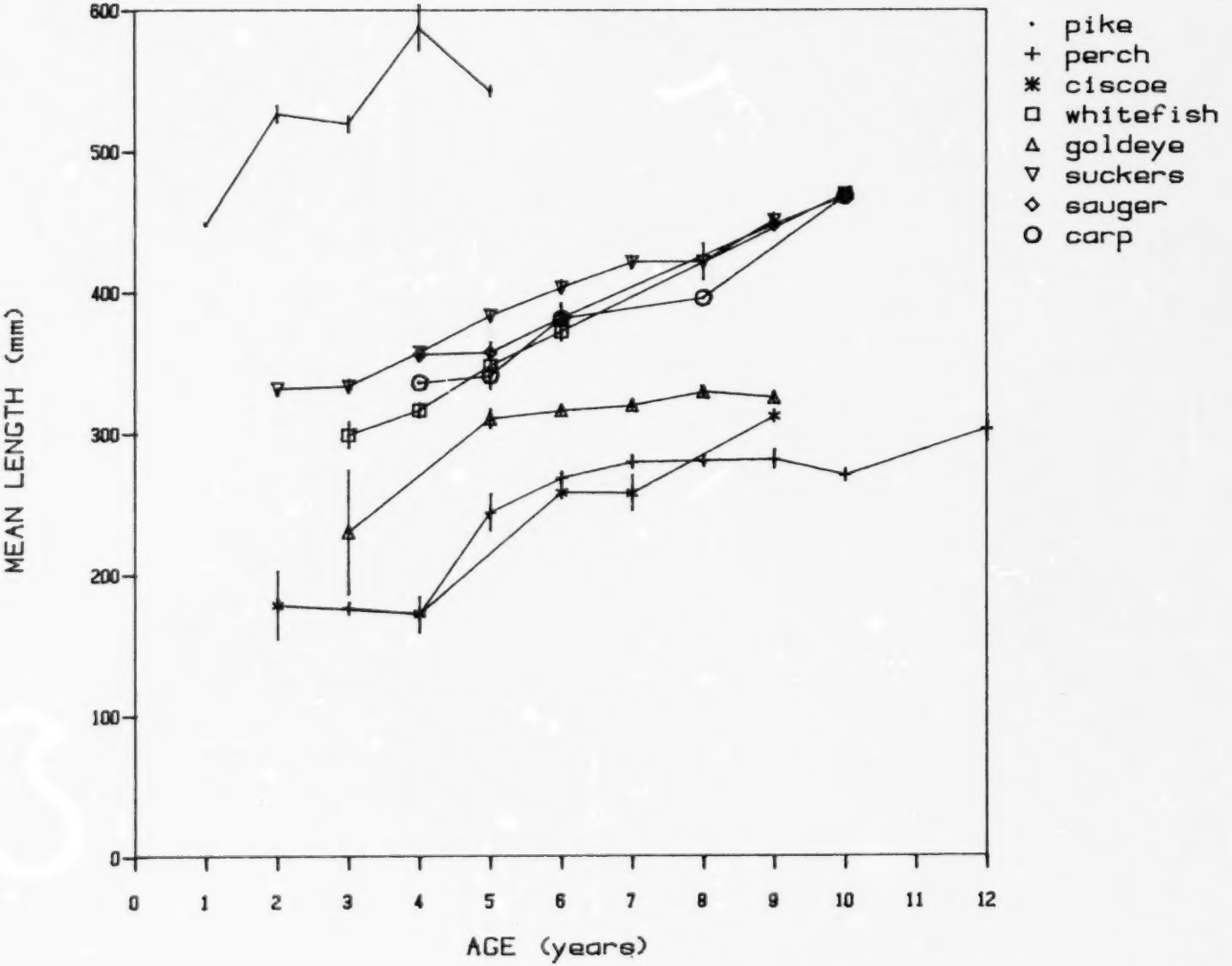


Fig. 30. Growth of L. Winnipegosis fish.

COMPOSITION OF CATCH BY SPECIES IN 5 YEAR PERIODS 1931/32 ~ 1950/51

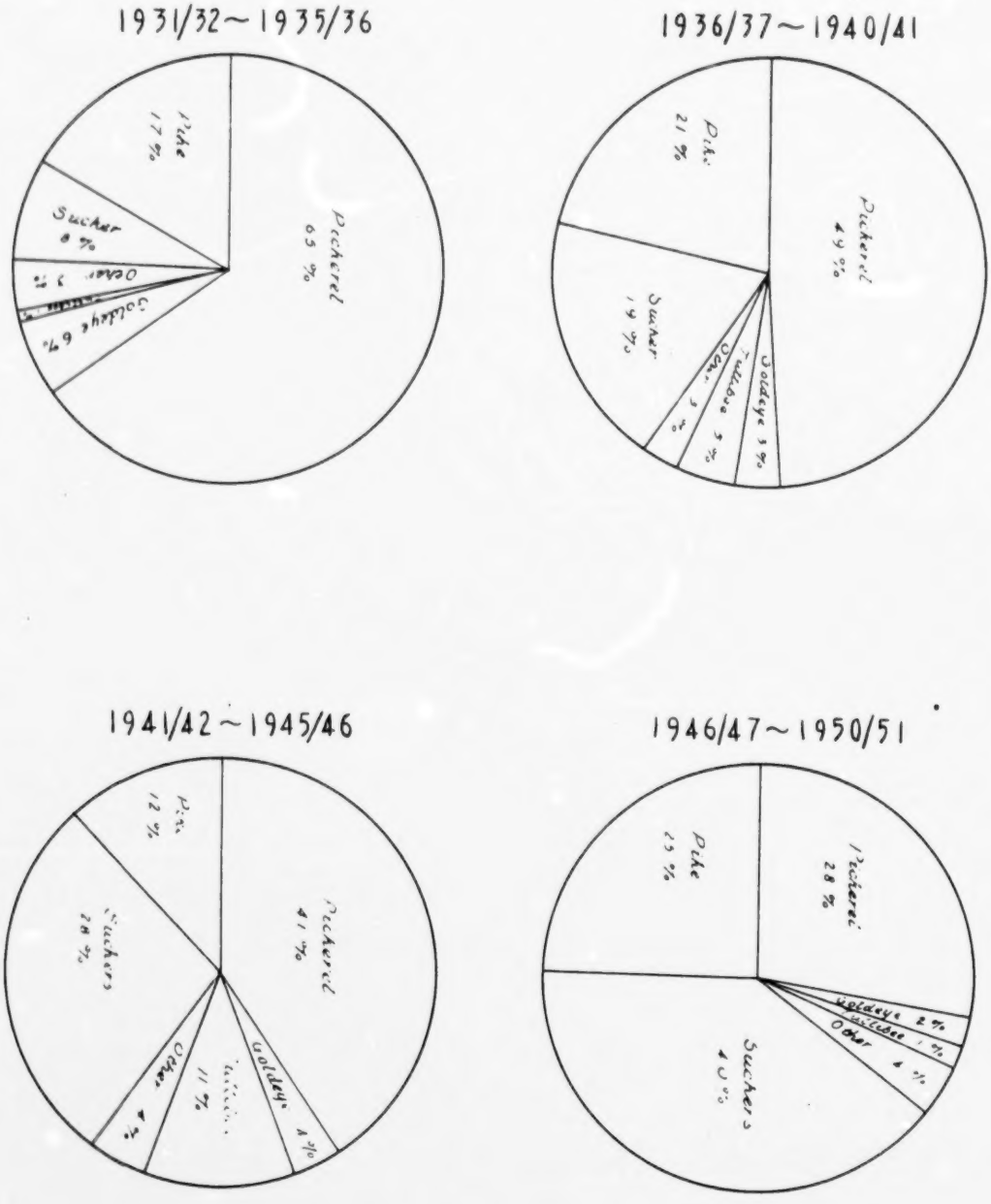
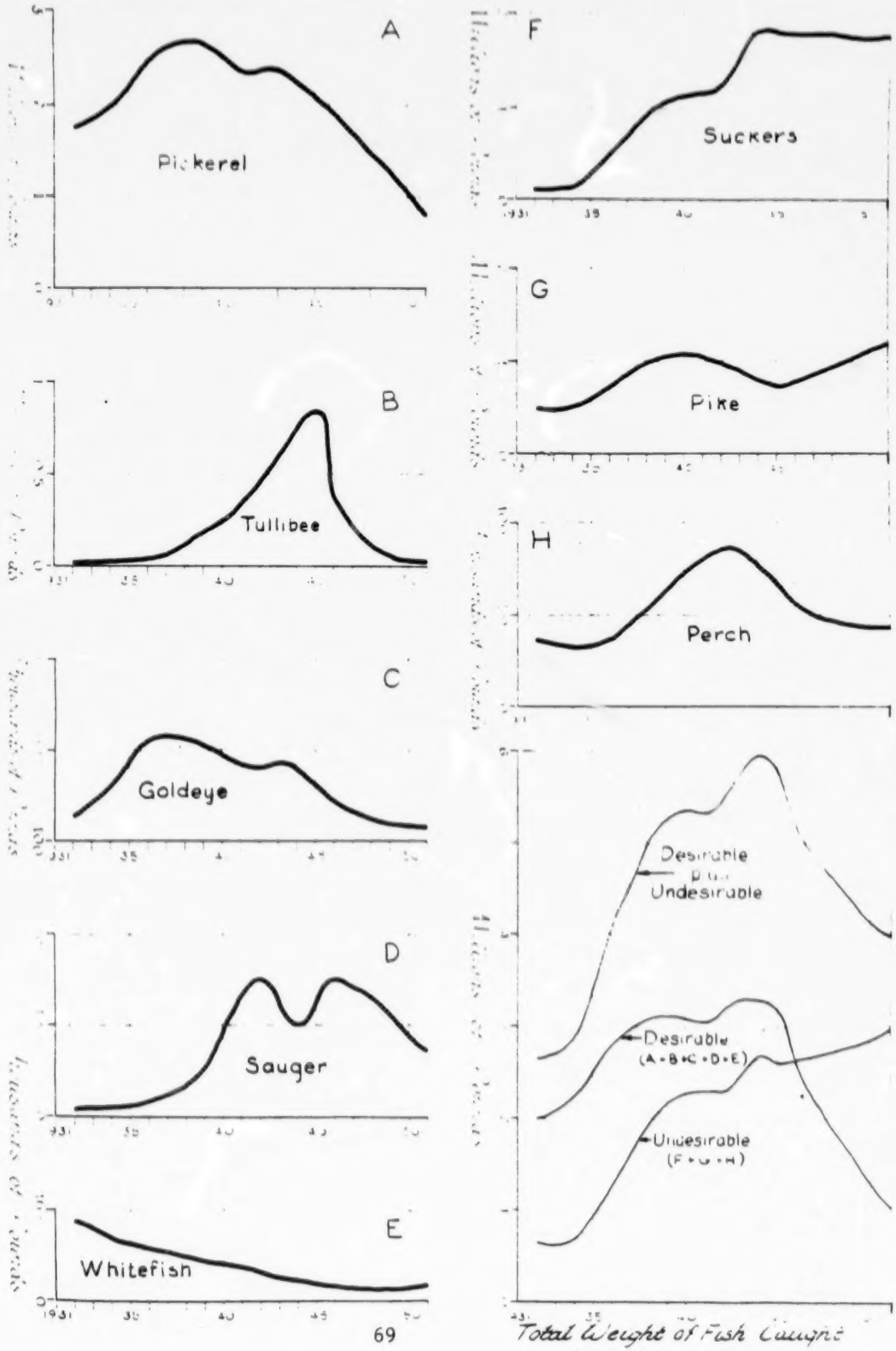


Fig. 31. Historical changes in species composition.

LAKE WINNIPEGOSIS

GRAPHS SHOWING TREND OF FISH POPULATION PER SPECIES 1931-1951



Total Weight of Fish Caught in Lake Winnipegosis

Fig. 32. Historical changes in commercial catches.

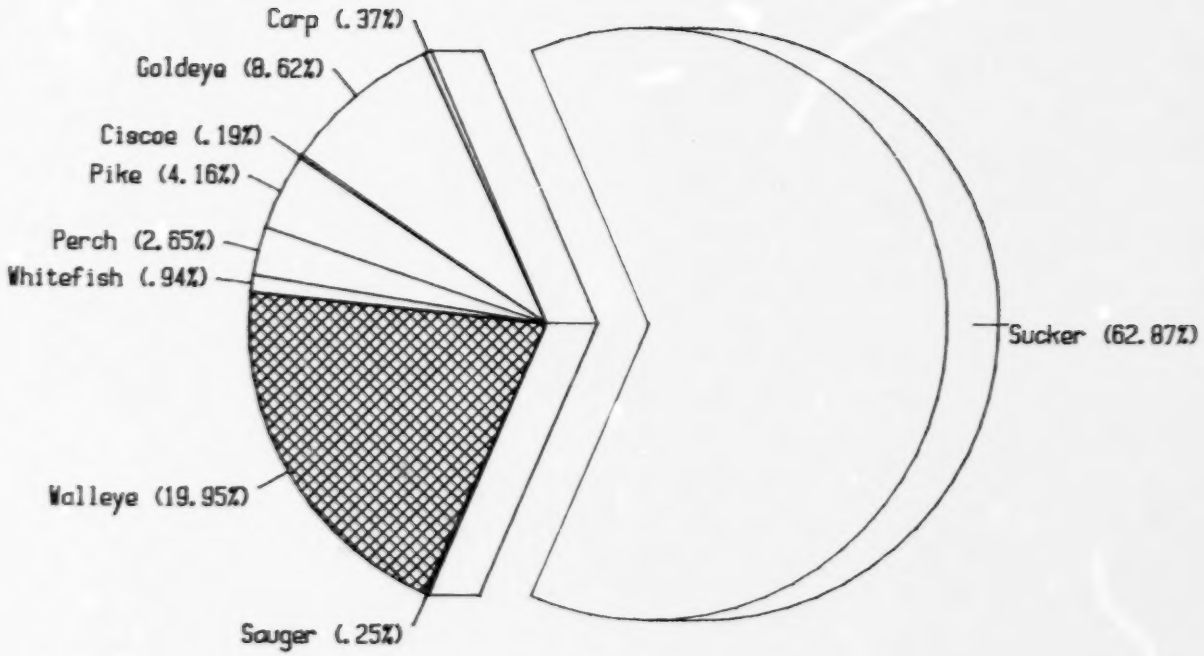


Fig. 33. Species composition from experimental gillnets, 1987.

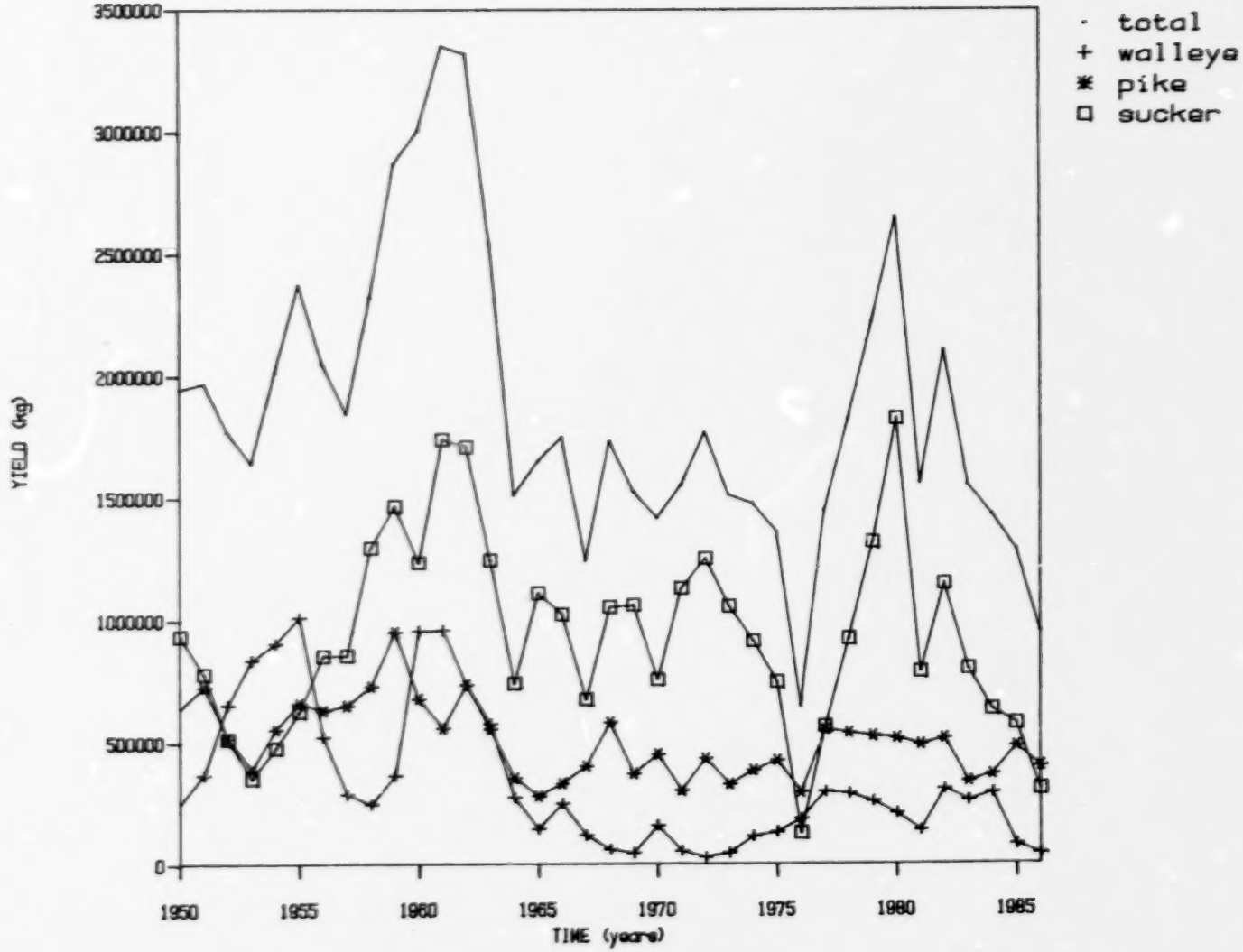


Fig. 34. Temporal changes in commercial yields of L. Winnipegosis.

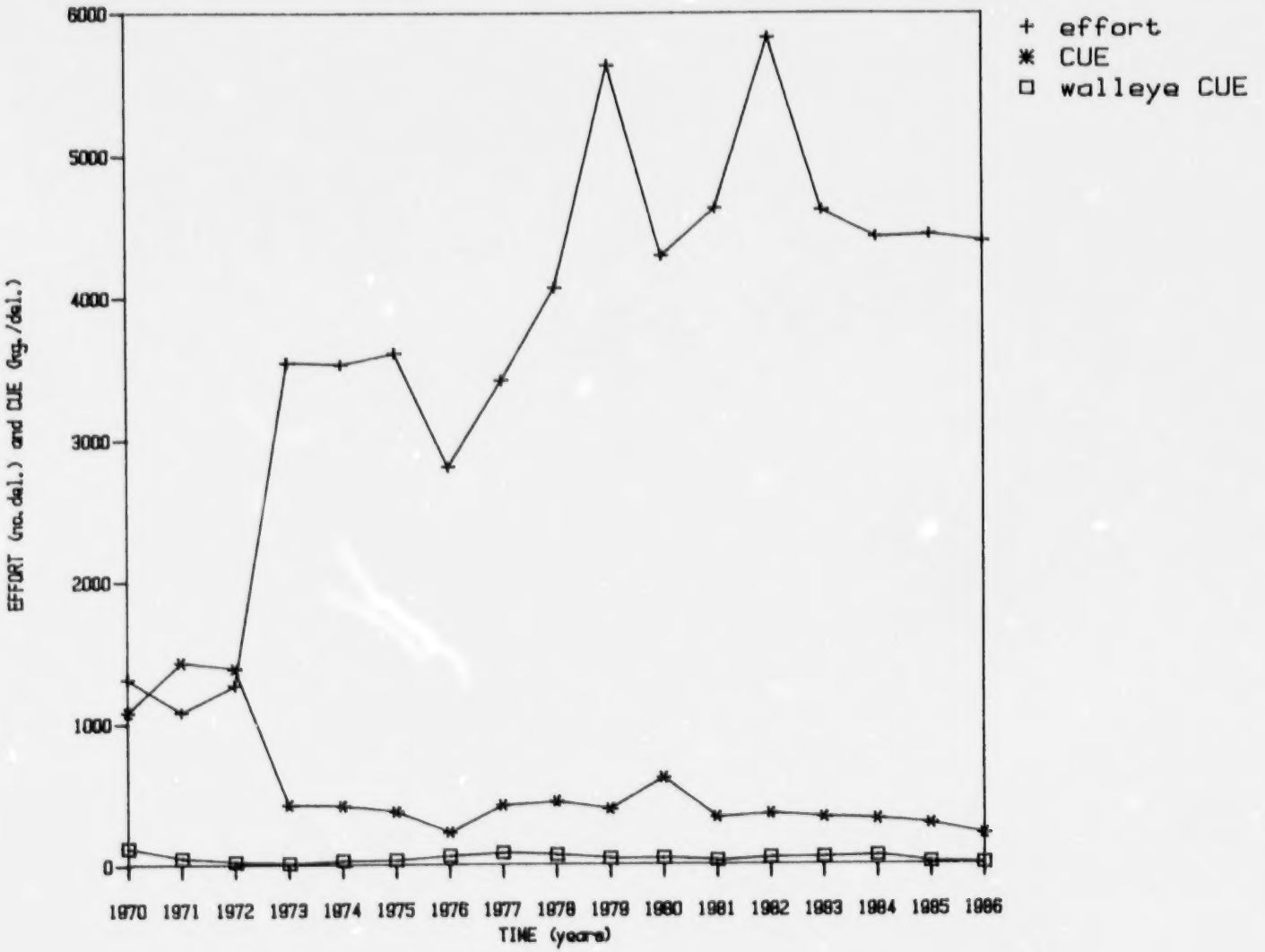


Fig. 35. Temporal changes in fishing effort and CUE on L. Winnipegosis.

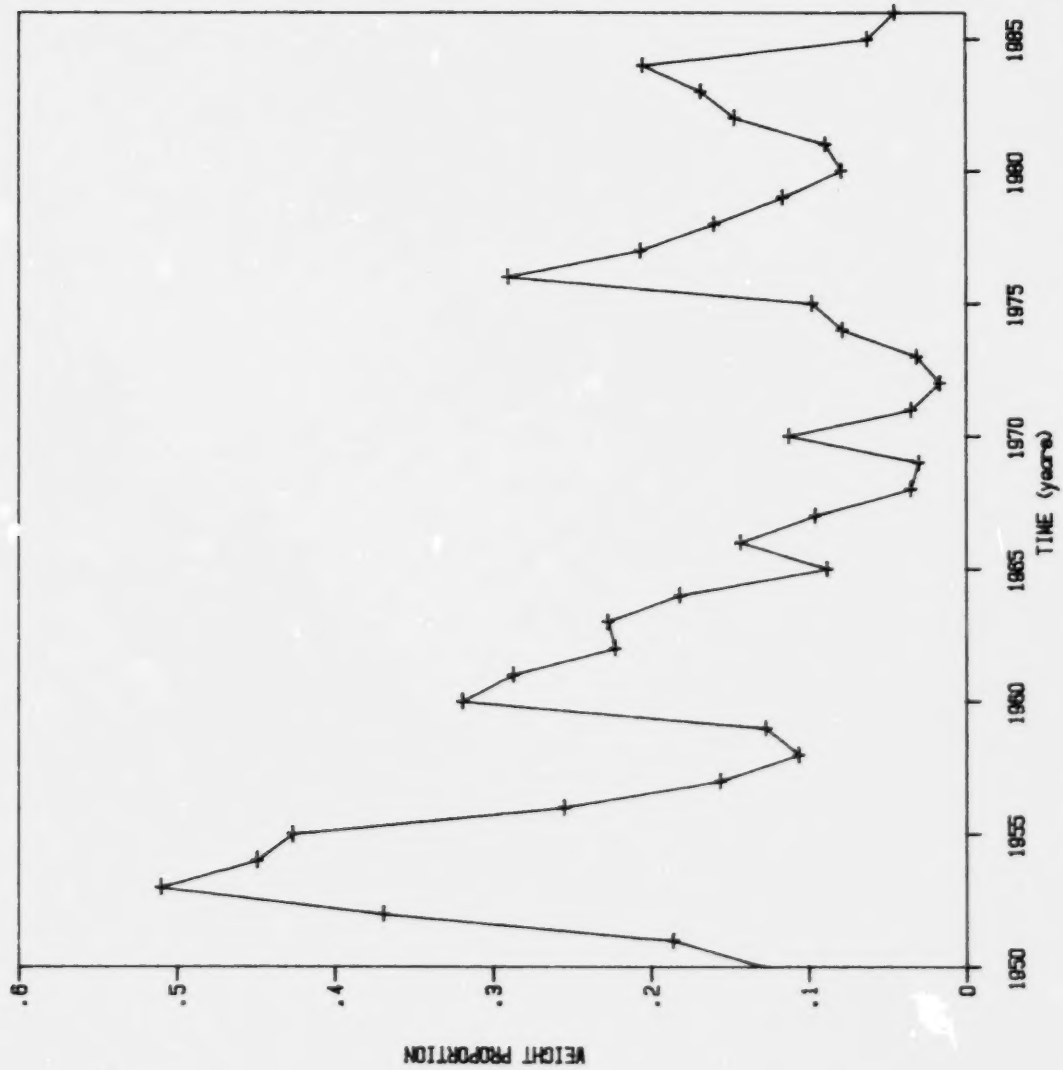


Fig. 36. Proportions of walleyes in catches from L. Winnipegosis.

will maximize total yields = 2,297,031 kg. (curve 1, Fig. 37.)

Tukey's jackknife analysis (Sokal and Rohlf 1981) of the lake Winnipegosis catch and effort data from 1973-1986 produced 15 MSY curves (Appendix C). The seventh curve produced the highest estimates of optimal catch (2,698,331 kg) and effort (10,227 deliveries) while the fifteenth curve produced the lowest estimate of optimal effort (6,069 deliveries) and a relatively low estimate of MSY (2,087,350 kg.) (Fig. 37). From 1973-1986, the mean weight proportion of commercial yields comprised of walleyes was 0.1264. Mean annual yields of walleyes observed during the following time periods were:

	1950-1986	: 336,755 kg.,	0.72 kg./ha.
pre-collapse	1950-1963	: 619,163 kg.,	1.33 kg./ha.
post-collapse	1964-1986	: 164,854 kg.,	0.35 kg./ha.

Assuming that application of the mean walleye weight proportion of commerical yields, 0.1264, to predicted MSY values is valid, then annual yields of walleyes are:

MSY curve 1 (Fig. 37)	: 290,345 kg.,	0.62 kg./ha.
MSY curve 15 (Fig. 37)	: 262,703 kg.,	0.56 kg./ha.
MSY curve 7 (Fig. 37)	: 341,069 kg.,	0.73 kg./ha.

The 1,000,000 pound annual walleye quota currently considered implies that 0.97 kg./ha. of walleyes is available for harvest.

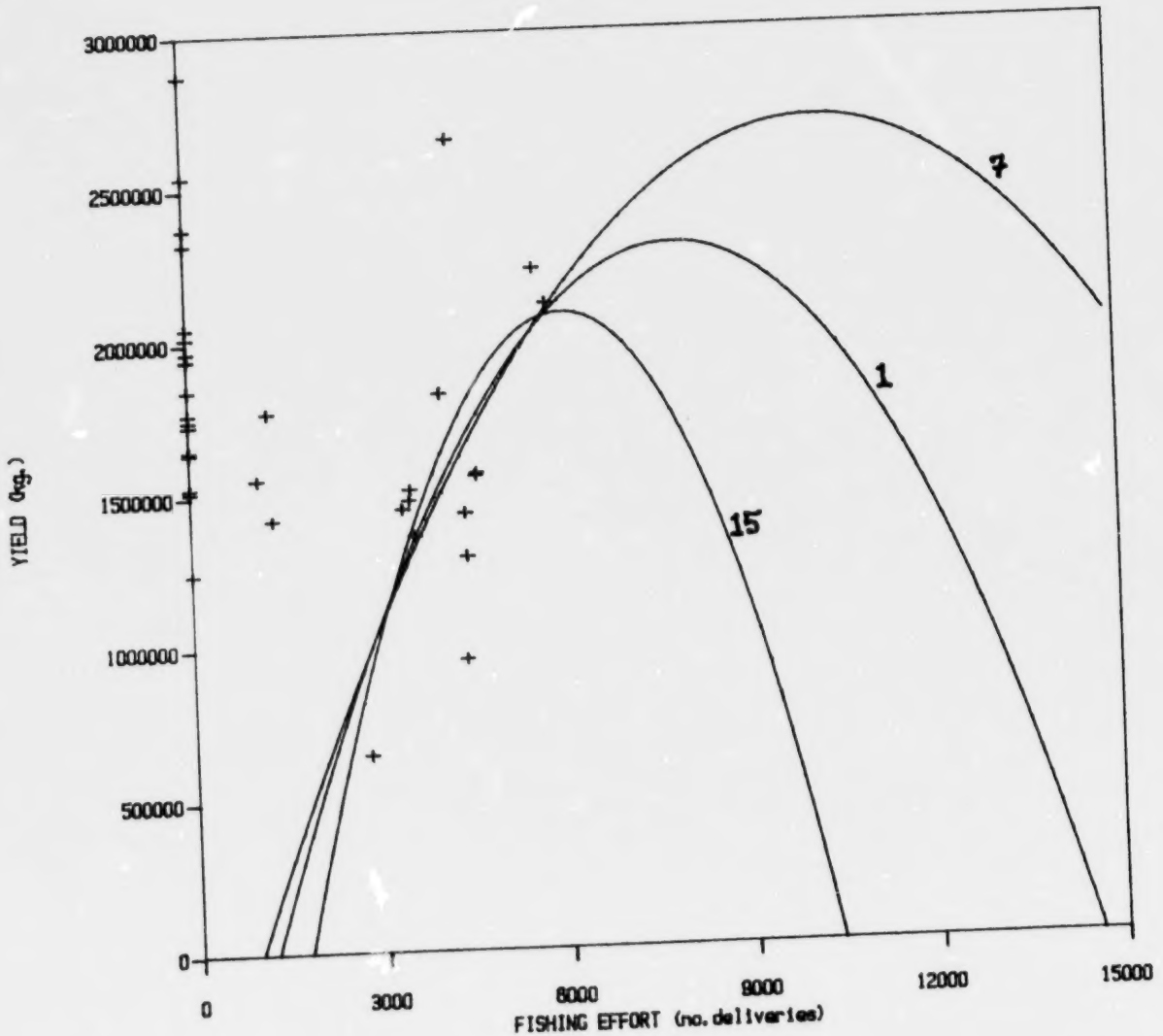


Fig. 37. Effects of fishing effort on total yields from L. Winnipegosis.

DISCUSSION

The maturity rate of Lake Winnipegosis' female walleyes, 1.841, was surpassed during only two years by female walleyes from the southern basin of Lake Winnipeg. The mean age of maturity of Lake Winnipegosis' female walleyes, 4.34 years, is lower than that of the Lake Winnipeg stock (5.28 - 7.54 years).

The L_{∞} estimate of the Lake Winnipegosis walleye stock, 578.5 mm., is comparable to the highest L_{∞} values of Lake Winnipeg's stocks. P, Pauly statistic is also similar between the two lakes' stocks (Lysack 1986).

From 1972-1983, Lake Winnipeg's fishermen harvested a mean of 0.51 kg./ha. of walleyes and a total catch of 1.78 kg./ha. by exerting fishing effort ranging from 23,108 - 32,492 deliveries (Lysack 1986).

In an attempt to increase walleye yields, Lake Winnipegosis' fishermen agreed to stop fishing during the open water season during the past few years. However, fishing effort has concomitantly increased during the winter seasons. Currently, an annual quota of 1,000,000 pounds of walleye is being considered. This quota was derived by calculating the long term mean annual yield of walleyes from 1931-1960. This time period was dominated by the "fishing up" phase and does not include the period when the fish community was destablized and major shifts in species composition occurred. It is wrong to assume that average yield = MSY (ICNAF 1976, Doubleday 1976, Beddington and May

1977). Doubleday (1976) demonstrated that "... in the presence of fluctuations in production, attempts to remove the MSY each year from a stock leads to disaster."

Other factors that control walleye production in the Lake Winnipegosis system are : substantial angling on the Red Deer, Overflowing and Waterhen Rivers, domestic consumption, emigration to Red Deer Lake and Shoal Lake where small commercial fisheries exist, removal of eggs by hatchery operations at Duck Bay and illegal harvesting. Most of these factors remain unquantified and were not included in determining the new proposed commercial quota. The operation of several walleye rearing ponds around the lake periphery provides protection against predation for newly hatched walleye fry for one to two months. Signs of improved recruitment in Dawson Bay may be related to the Steeprock rearing pond production of young walleyes. Green and Derksen (1982) estimated that the more southerly rearing ponds contributed less than 1% to recruited walleye cohorts.

Since the 1930's the Lake Winnipegosis fishery has displayed changes in productivity, the size of dominant species and species diversity. Intensified fishing stress from 1950-1963 caused a shift in species dominance to more opportunistic shorter-lived species. Homeostatic mechanisms such as compensatory growth and maturity of the walleye stocks are presently operating at the upper limit of their scope in Manitoban waters. These symptoms all indicate the inability of the walleye stock to cope with further exploitation stress. User groups and

fisheries managers are now confronted with deciding whether to trade long term lower economic benefits for short term optimal benefits.

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APPENDIX A.

MATURITY ANALYSIS OF WALLEYES

1987 L.Winnipegosis walleyes

case	(X)age (years)	(Y)mature females (%)
1	0	0.00
2	1	0.00
3	2	0.00
4	3	4.32
5	4	57.89
6	5	100.00
7	6	93.94
8	7	100.00

Transformed data

case	(X) age (years)	(Y) log(100-y/y)
1	3	-3.097515
2	4	.3184539
3	6	2.74084

REGRESSION

Equation: log(100-y/y)=-7.990963 +1.841128*age (years)
Variance: 1.388872
S.E.(slope): .6429228
95% C.I.(slope): 13.88512 -12.04399 < 1.841128 < 15.72625
S.E.(intercept): 2.459983
95% C.I.(intercept): 62.61147 -70.60243 <-7.990963 < 54.62051
Correlation coefficient,r: .9587949
Proportion of variability due to regression,r^2: .9192878

Mean age of maturity= 4.340254

ANOVA

SOURCE	d.f.	SS	MS	F
Total	2	17.21	8.60	
Regression	1	15.82	15.82	11.39
Error	1	1.39	1.39	

Test F< 161 non-significant regression

L.Winnipegosis male walleyes

case	(X)age (years)	(Y)mature males (%)
1	0	0.00
2	1	0.00
3	2	8.82
4	3	53.17
5	4	91.74
6	5	100.00
7	6	90.00
8	7	100.00

Transformed data

case	(X) age (years)	(Y) log(100-y/y)
1	2	-2.335375
2	3	.1271555
3	4	2.407946

REGRESSION

Equation: log(100-y/y)=-7.048405 +2.37166*age (years)
Variance: 5.505562E-03
S.E.(slope): 3.89302E-03
95% C.I.(slope): 1.335389 1.036272 < 2.37166 < 3.707049
S.E.(intercept): .1631264
95% C.I.(intercept): 4.151893 -11.2003 <-7.048405 <-2.896513
Correlation coefficient,r: .9997554
Proportion of variability due to regression,r^2: .9995108

Mean age of maturity= 2.971929

ANOVA

SOURCE	d.f.	SS	MS	F
Total	2	11.26	5.63	
Regression	1	11.25	11.25	2043.31
Error	1	0.01	0.01	

Test F=> 161 significant regression

APPENDIX B.

GROWTH ANALYSIS OF WALLEYES

1987 L.Winnipegosis walleyes

case	(X)length (mm)	(Y)length (mm)
1	0.00	0.00
2	226.00	226.00
3	318.57	318.57
4	382.94	382.94
5	436.56	436.56
6	465.67	465.67
7	487.42	487.42
8	522.00	522.00

Transformed data

case	(X) Lt	(Y) Lt+1
1	226	318.5714
2	318.5714	382.9445
3	382.9445	436.5556
4	436.5556	465.6667
5	465.6667	487.4186
6	487.4186	522

REGRESSION

Equation: Lt+1= 148.4258 +.743412*Lt
Variance: 63.15918
S.E.(slope): .284328
95% C.I.(slope): .1250399 .6183721 < .743412 < .8684519
S.E.(intercept): 14.19256
95% C.I.(intercept): 49.60301 98.82274 < 148.4258 < 198.0288
Correlation coefficient,r: .9953999
Proportion of variability due to regression,r^2: .9908211

L inf.= 578.4595

ANOVA

SOURCE	d.f.	SS	MS	F
Total	5	27523.13	5504.63	
Regression	1	27270.49	27270.49	431.77
Error	4	252.64	63.16	

Test F=> 7.71 significant regression

1987 L.Winnipegosis walleyes

case	(X)age (years)	(Y)length (mm)
1	0	0.00
2	1	226.00
3	2	318.57
4	3	382.94
5	4	436.56
6	5	465.67
7	6	487.42
8	7	522.00

Transformed data

case	(X) age (years)	(Y) log(578.5-Lt)
1	1	5.865051
2	2	5.560406
3	3	5.275845
4	4	4.955436
5	5	4.725912
6	6	4.511754
7	7	4.034241

REGRESSION

Equation: log(578.5-Lt)= 6.152616 -.2907023*age (years)
Variance: 3.94435E-03
S.E.(slope): 7.45412E-04
95% C.I.(slope): 3.754118E-02 -.3282435 <-.2907023 <-.2531611
S.E.(intercept): 5.307912E-02
95% C.I.(intercept): .1678892 5.984727 < 6.152616 < 6.320505
Correlation coefficient,r:-.9958585
Proportion of variability due to regression,r^2: .9917341

L inf.= 578.5
Brody's K= .2907023
To(years)=-.7148991

ANOVA

SOURCE	d.f.	SS	MS	F
Total	6	2.39	0.40	
Regression	1	2.37	2.37	599.90
Error	5	0.02	0.00	

Test F=) 6.61 significant regression

L.Winnipegosis male walleyes

case	(X)length (mm)	(Y)length (mm)
1	0.00	0.00
2	0.00	0.00
3	315.88	315.88
4	383.08	383.08
5	429.59	429.59
6	446.35	446.35
7	467.60	467.60
8	490.00	490.00

Transformed data

case	(X) Lt	(Y) Lt+1
1	315.8824	383.0794
2	383.0794	429.5872
3	429.5872	446.3462
4	446.3462	467.6
5	467.6	490

REGRESSION

Equation: Lt+1= 172.6536 +.662594*Lt
Variance: 62.69027
S.E.(slope): .5199339
95% C.I.(slope): .2736985 .3888955 < .662594 < .9362925
S.E.(intercept): 27.0065
95% C.I.(intercept): 112.7792 59.87445 < 172.6536 < 285.4328
Correlation coefficient,r: .9856391
Proportion of variability due to regression,r^2: .9714844

L inf.= 511.7087

ANOVA

SOURCE	d.f.	SS	MS	F
Total	4	6595.31	1648.83	
Regression	1	6407.24	6407.24	102.20
Error	3	188.07	62.69	

Test F=> 10.13 significant regression

L.Winnipegosis male walleyes

case	(X)age (years)	(Y)length (mm)
1	0	0.00
2	1	0.00
3	2	315.88
4	3	383.08
5	4	429.59
6	5	446.35
7	6	467.60
8	7	490.00

Transformed data

case	(X) age (years)	(Y) log(511.7-Lt)
1	2	5.277184
2	3	4.856867
3	4	4.408095
4	5	4.179816
5	6	3.78646
6	7	3.077313

REGRESSION

Equation: log(511.7-Lt)= 6.120711 -.4125384*age (years)
Variance: 1.597178E-02
S.E.(slope): 3.817986E-03
95% C.I.(slope): .1055856 -.518124 <-.4125384 <-.3069527
S.E.(intercept): .1454084
95% C.I.(intercept): .5082022 5.612509 < 6.120711 < 6.628913
Correlation coefficient,r:-.9894441
Proportion of variability due to regression,r^2: .9789996

L inf.= 511.7
Brody's K= .4125384
To(years)=-.2836761

ANOVA

SOURCE	d.f.	SS	MS	F
Total	5	3.04	0.61	
Regression	1	2.98	2.98	186.47
Error	4	0.06	0.02	

Test F=> 7.71 significant regression

L.Winnipegosis female walleyes

case	(X)length (mm)	(Y)length (mm)
1	0.00	0.00
2	226.00	226.00
3	320.70	320.70
4	382.84	382.84
5	441.55	441.55
6	472.55	472.55
7	493.42	493.42
8	538.00	538.00

Transformed data

case	(X) Lt	(Y) Lt+1
1	226	320.6977
2	320.6977	382.8395
3	382.8395	441.5527
4	441.5527	472.548
5	472.548	493.4243
6	493.4243	538

REGRESSION

Equation: Lt+1= 143.3305 +.7655248*Lt
Variance: 145.4185
S.E.(slope): .6382117
95% C.I.(slope): .1849704 .5805544 < .7655248 < .9504951
S.E.(intercept): 21.19426
95% C.I.(intercept): 74.07391 69.25663 < 143.3305 < 217.4045
Correlation coefficient,r: .9905758
Proportion of variability due to regression,r^2: .9812404

L inf.= 611.2821

ANOVA

SOURCE	d.f.	SS	MS	F
Total	5	31006.50	6201.30	
Regression	1	30424.83	30424.83	209.22
Error	4	581.67	145.42	

Test F=> 7.71 significant regression

REGRESSION

Equation: Lt+1= 159.9359 +.7113018*Lt
Variance: 40.89323
S.E.(slope): .2071789
95% C.I.(slope): .1352945 .5760073 < .7113018 < .8465964
S.E.(intercept): 12.28363
95% C.I.(intercept): 51.29642 108.6394 < 159.9359 < 211.2323
Correlation coefficient,r: .9969026
Proportion of variability due to regression,r^2: .9938148

L inf.= 553.9898

ANOVA

SOURCE	d.f.	SS	MS	F
Total	4	19834.19	4958.55	
Regression	1	19711.51	19711.51	482.02
Error	3	122.68	40.89	

Test F=> 10.13 significant regression

L.Winnipegosis female walleyes

case	(X)age (years)	(Y)length (mm)
1	0	0.00
2	1	226.00
3	2	320.70
4	3	382.84
5	4	441.55
6	5	472.55
7	6	493.42
8	7	538.00

Transformed data

case	(X) age (years)	(Y) log(554-Lt)
1	1	5.793013
2	2	5.452735
3	3	5.142502
4	4	4.722485
5	5	4.400014
6	6	4.103894
7	7	2.772589

REGRESSION

Equation: log(554-Lt)= 6.412526 -.4464553*age (years)
Variance: 9.974356E-02
S.E.(slope): 1.884976E-02
95% C.I.(slope): .1887829 -.6352382 <-.4464553 <-.2576724
S.E.(intercept): .2669183
95% C.I.(intercept): .8442628 5.568263 < 6.412526 < 7.256789
Correlation coefficient,r:-.9581078
Proportion of variability due to regression,r^2: .9179706

L inf.= 554
Brody's k= .4464553
To(years)= .2135964

ANOVA

SOURCE	d.f.	SS	MS	F
Total	6	6.08	1.01	
Regression	1	5.58	5.58	55.95
Error	5	0.50	0.10	

Test F=> 6.61 significant regression

L.Winnipegosis walleyes (north)

case	(X)length (mm)	(Y)length (mm)
1	0.00	0.00
2	242.00	242.00
3	315.25	315.25
4	375.44	375.44
5	439.01	439.01
6	467.29	467.29
7	492.00	492.00
8	522.00	522.00

Transformed data

case	(X) Lt	(Y) Lt+1
1	242	315.25
2	315.25	375.443
3	375.443	439.0134
4	439.0134	467.2942
5	467.2942	492
6	492	522

REGRESSION

Equation: Lt+1= 126.006 +.7957805*Lt
Variance: 83.89844
S.E.(slope): .3891919
95% C.I.(slope): .1485026 .6472778 < .7957805 < .944283
S.E.(intercept): 16.92561
95% C.I.(intercept): 59.15501 66.85097 < 126.006 < 185.161
Correlation coefficient,r: .9943465
Proportion of variability due to regression,r^2: .9887249

L inf.= 617.0123

ANOVA

SOURCE	d.f.	SS	MS	F
Total	5	29764.00	5952.80	
Regression	1	29428.41	29428.41	350.76
Error	4	335.59	83.90	

Test F=> 7.71 significant regression

L.Winnipegosis walleyes (north)

case	(X)age (years)	(Y)length (mm)
1	0	0.00
2	1	242.00
3	2	315.25
4	3	375.44
5	4	439.01
6	5	467.29
7	6	492.00
8	7	522.00

Transformed data

case	(X) age (years)	(Y) log(617-Lt)
1	1	5.926926
2	2	5.709599
3	3	5.487106
4	4	5.181709
5	5	5.008672
6	6	4.828314
7	7	4.553877

REGRESSION

Equation: log(617-Lt)= 6.150911 -.2271489*age (years)
Variance: 1.168227E-03
S.E.(slope): 2.207742E-04
95% C.I.(slope): 2.043073E-02 -.2475796 <-.2271489 <-.2067182
S.E.(intercept): 2.888681E-02
95% C.I.(intercept): 9.136899E-02 6.059541 < 6.150911 < 6.24228
Correlation coefficient,r:-.9979845
Proportion of variability due to regression,r^2: .9959731

L inf.= 617
Brody's K= .2271489
To(years)=-1.206075

ANOVA

SOURCE	d.f.	SS	MS	F
Total	6	1.45	0.24	
Regression	1	1.44	1.44	1236.66
Error	5	0.01	0.00	

Test F=> 6.61 significant regression

L.Winnipegosis walleyes (Duck Bay)

case	(X)length (mm)	(Y)length (mm)
1	0.00	0.00
2	0.00	0.00
3	336.83	336.83
4	387.61	387.61
5	441.12	441.12
6	467.42	467.42
7	487.15	487.15
8	490.00	490.00

Transformed data

case	(X) Lt	(Y) Lt+1
1	336.8334	387.6051
2	387.6051	441.1177
3	441.1177	467.4167
4	467.4167	487.1515
5	487.1515	490

REGRESSION

Equation: Lt+1= 168.0553 +.6759106*Lt
Variance: 84.60254
S.E.(slope): .6887452
95% C.I.(slope): .3126996 < .363211 < .6759106 < .9886102
S.E.(intercept): 32.01641
95% C.I.(intercept): 133.7005 < 34.35475 < 168.0553 < 301.7558
Correlation coefficient,r: .9820836
Proportion of variability due to regression,r^2: .9644882

L inf.= 518.5461

ANOVA

SOURCE	d.f.	SS	MS	F
Total	4	7147.13	1786.78	
Regression	1	6893.32	6893.32	81.48
Error	3	253.81	84.60	

Test F=> 10.13 significant regression

L.Winnipegosis walleyes (Duck Bay)

case	(X)age (years)	(Y)length (mm)
1	0	0.00
2	1	0.00
3	2	336.83
4	3	387.61
5	4	441.12
6	5	467.42
7	6	487.15
8	7	490.00

Transformed data

case	(X) age (years)	(Y) log(518.5-Lt)
1	2	5.202173
2	3	4.874395
3	4	4.348758
4	5	3.933458
5	6	3.445167
6	7	3.349904

REGRESSION

Equation: log(518.5-Lt)= 5.987725 -.3989812*age (years)
Variance: 1.466107E-02
S.E.(slope): 3.504667E-03
95% C.I.(slope): .1011605 -.5001417 <-.3989812 <-.2978206
S.E.(intercept): .1[illegible]3143
95% C.I.(intercept): .4869034 5.500821 < 5.987725 < 6.474628
Correlation coefficient,r:-.9896376
Proportion of variability due to regression,r^2: .9793826

L inf.= 518.5
Brody's K= .3989812
To(years)=-.6597193

ANOVA

SOURCE	d.f.	SS	MS	F
Total	5	2.84	0.57	
Regression	1	2.79	2.79	190.01
Error	4	0.06	0.01	

Test F=> 7.71 significant regression

L.Winnipegosis walleyes (south)

case	(X)length (mm)	(Y)length (mm)
1	0.00	0.00
2	210.00	210.00
3	312.00	312.00
4	380.27	380.27
5	420.77	420.77
6	457.47	457.47
7	487.38	487.38
8	554.00	554.00

Transformed data

case	(X) Lt	(Y) Lt+1
1	210	312
2	312	380.2692
3	380.2692	420.7675
4	420.7675	457.4706
5	457.4706	487.375
6	487.375	554

REGRESSION

Equation: Lt+1= 131.2892 +.8043395*Lt
Variance: 411.3633
S.E.(slope): 1.792051
95% C.I.(slope): .3088053 .4955343 < .8043395 < 1.113145
S.E.(intercept): 34.40809
95% C.I.(intercept): 120.2563 11.03288 < 131.2892 < 251.5455
Correlation coefficient,r: .9767061
Proportion of variability due to regression,r^2: .9539549

L inf.= 671.005

ANOVA

SOURCE	d.f.	SS	MS	F
Total	5	35735.63	7147.13	
Regression	1	34090.17	34090.17	82.87
Error	4	1645.45	411.36	

Test F=> 7.71 significant regression

REGRESSION (case 6 deleted)

Equation: Lt+1= 162.5841 +.6992177*Lt
Variance: 30.34375
S.E.(slope): .1549843
95% C.I.(slope): .1174935 .5817243 < .6992177 < .8167111
S.E.(intercept): 10.31747
95% C.I.(intercept): 43.08578 119.4983 < 162.5841 < 205.6698
Correlation coefficient,r: .9975801
Proportion of variability due to regression,r^2: .9951661

L inf.= 540.5373

ANOVA

SOURCE	d.f.	SS	MS	F
Total	4	18831.81	4707.95	
Regression	1	18740.78	18740.78	617.62
Error	3	91.03	30.34	

Test F=> 10.13 significant regression

L.Winnipegosis walleyes (south)

case	(X)age (years)	(Y)length (mm)
1	0	0.00
2	1	210.00
3	2	312.00
4	3	380.27
5	4	420.77
6	5	457.47
7	6	487.38
8	7	554.00

Transformed data

case	(X) age (years)	(Y) log(540.5-Lt)
1	1	5.800607
2	2	5.431536
3	3	5.076516
4	4	4.78526
5	5	4.419195
6	6	3.97[illegible]48

REGRESSION

Equation: log(540.5-Lt)= 6.161125 -.356233*age (years)
Variance: 1.780331E-03
S.E.(slope): 4.255806E-04
95% C.I.(slope): 3.525158E-02 -.3914846 <-.356233 <-.3209814
S.E.(intercept): 3.928045E-02
95% C.I.(intercept): .1372852 6.02384 < 6.161125 < 6.298411
Correlation coefficient,r:-.9984006
Proportion of variability due to regression,r^2: .9968037

L inf.= 540.5
Brody's K= .356233
To(years)=-.3687744

ANOVA

SOURCE	d.f.	SS	MS	F
Total	5	2.23	0.45	
Regression	1	2.22	2.22	1247.40
Error	4	0.01	0.00	

Test F=> 7.71 significant regression

APPENDIX C.

COMMERCIAL YIELDS (kg.) AND CATCH - EFFORT RELATIONSHIPS

CASE	YEAR	WALLEYE	PIKE	WHITEFISH	GOLDEYE	SAUGER
1	1950	248730	640472	11524	36252	34075
2	1951	366198	727768	9891	7033	30672
3	1952	653539	519783	5354	6534	29628
4	1953	836979	388294	5490	5445	15835
5	1954	905264	553948	9120	10119	21507
6	1955	1010889	661117	7623	7940	32260
7	1956	520826	630717	12205	5626	14882
8	1957	286978	652405	13884	11343	17105
9	1958	245690	731534	7033	4311	25953
10	1959	363884	952768	17197	2587	47641
11	1960	957351	678766	25817	1089	57214
12	1961	960254	559256	13113	953	31624
13	1962	735890	737069	47324	907	41470
14	1963	575817	555037	50998	2178	66742
15	1964	273957	354174	14565	1498	73321
16	1965	144737	280853	15608	4900	65835
17	1966	249773	332804	12750	10481	74274
18	1967	118467	404038	9347	8485	16334
19	1968	60345	582849	10481	7849	14247
20	1969	45100	372097	24819	7759	12568
21	1970	158930	450908	7805	21234	17786
22	1971	53449	304084	17741	30082	11887
23	1972	28904	434392	29538	15925	6261
24	1973	47084	328685	63652	9717	4421
25	1974	115403	386568	42906	11253	4082
26	1975	132639	426291	41797	7964	1885
27	1976	187302	296784	25154	3460	2631
28	1977	297537	552095	25638	3355	1663
29	1978	290150	539868	63956	2847	838
30	1979	257624	526532	105126	2939	1992
31	1980	208442	517105	64388	1070	539
32	1981	138855	491835	68694	651	682
33	1982	308425	515674	64229	3704	405
34	1983	260035	339790	63452	7137	2134
35	1984	292394	368345	63082	25923	4814
36	1985	79722	483875	75025	20989	1997
37	1986	42371	400325	54917	20132	6021

CASE	SUCKER	CARP	PERCH	CISCOE	TOTAL	EFFORT
1	935935	0	32487	6988	1946463	M
2	781625	0	34936	11525	1969648	M
3	513884	0	27315	13113	1769150	M
4	352268	0	22459	14202	1640972	M
5	477858	0	33076	5853	2016745	M
6	627587	0	23458	1225	2372099	M
7	856125	0	4854	1996	2047231	M
8	857895	0	4492	408	1844510	M
9	1296598	0	8848	2178	2322145	M
10	1467741	0	11797	6715	2870330	M
11	1235980	0	44057	2541	3002815	M
12	1741152	0	39973	3857	3350182	M
13	1709982	0	43874	1497	3318013	M
14	1246007	0	41743	1135	2539657	M
15	743602	0	52042	0	1513159	M
16	1111843	0	26452	182	1650410	M
17	1025092	2903	40381	590	1749048	M
18	677359	1679	7668	136	1243513	M
19	1054810	0	2042	136	1732759	M
20	1063340	0	1180	0	1526863	M
21	757805	0	3766	0	1418242	1314
22	1131216	0	2223	0	1550682	1082
23	1252405	0	1407	0	1768830	1272
24	1056094	0	425	0	1510078	3544
25	914818	0	418	0	1475448	3530
26	747178	374	1017	0	1359145	3609
27	128227	619	2140	0	646317	2807
28	567255	0	644	0	1448187	3416
29	925006	0	221	0	1822886	4065
30	1319491	8248	482	0	2222434	5633
31	1825903	30397	759	0	2648603	4290
32	789857	67952	906	0	1559432	4627
33	1147729	65580	1423	0	2107169	5827
34	800656	76687	833	9	1550733	4614
35	633218	36460	5498	3	1429737	4423
36	575287	42331	8886	11	1288123	4442
37	307806	109529	10960	0	952062	4393

CASE	CUE	WACUE	WAFRED
1	M	M	0.1278
2	M	M	0.1859
3	M	M	0.3694
4	M	M	0.5101
5	M	M	0.4489
6	M	M	0.4262
7	M	M	0.2544
8	M	M	0.1556
9	M	M	0.1058
10	M	M	0.1268
11	M	M	0.3188
12	M	M	0.2866
13	M	M	0.2218
14	M	M	0.2267
15	M	M	0.1810
16	M	M	0.0877
17	M	M	0.1428
18	M	M	0.0953
19	M	M	0.0348
20	M	M	0.0295
21	1079.3	120.96	0.1121
22	1433.2	49.398	0.0345
23	1390.6	22.722	0.0163
24	426.09	13.286	0.0312
25	417.97	32.692	0.0782
26	376.60	36.752	0.0976
27	230.25	66.727	0.2898
28	423.94	87.101	0.2055
29	448.43	71.378	0.1592
30	394.54	45.735	0.1159
31	617.39	48.588	0.0787
32	337.03	30.010	0.0890
33	361.62	52.930	0.1464
34	336.09	56.358	0.1677
35	323.25	66.108	0.2045
36	289.99	17.947	0.0619
37	216.72	9.6451	0.0445

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL Curve 1 1973-1986

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-9.0086E+05	2.7959E+06	-0.32	0.7533
EFFORT	809.03	1297.3	0.62	0.5456
E2	-5.1170E-02	1.4724E-01	-0.35	0.7347

CASES INCLUDED	14	MISSING CASES	0
DEGREES OF FREEDOM	11		
OVERALL F	3.060	P VALUE	0.0735
ADJUSTED R SQUARED	0.2406		
R SQUARED	0.3575		
RESID. MEAN SQUARE	1.956E+11		

MSY = 2297031 kg

EFFORT = 7905.47 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL Curve 2 omit 1973

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-9.9757E+05	2.9138E+06	-0.34	0.7392
EFFORT	831.36	1349.0	0.62	0.5515
E2	-5.1867E-02	1.5300E-01	-0.34	0.7416

CASES INCLUDED	13	MISSING CASES	0
DEGREES OF FREEDOM	10		
OVERALL F	2.918	P VALUE	0.0868
ADJUSTED R SQUARED	0.2422		
R SQUARED	0.3685		
RESID. MEAN SQUARE	2.111E+11		

MSY = 2333833 kg.

EFFORT = 8014.34 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 3 omit 1974

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-9.9299E+05	2.9236E+06	-0.34	0.7412
EFFORT	832.42	1353.0	0.62	0.5522
E2	-5.2234E-02	1.5342E-01	-0.34	0.7406

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.862	P VALUE	0.0904
ADJUSTED R SQUARED	0.2369		
R SQUARED	0.3641		
RESID. MEAN SQUARE	2.123E+11		

MSY = 2323447 kg.

EFFORT = 7968.18 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 4 omit 1975

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-9.0245E+05	2.9342E+06	-0.31	0.7647
EFFORT	809.01	1360.6	0.59	0.5653
E2	-5.1107E-02	1.5447E-01	-0.33	0.7476

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.668	P VALUE	0.1047
ADJUSTED R SQUARED	0.2175		
R SQUARED	0.3479		
RESID. MEAN SQUARE	2.151E+11		

MSY = 2299073 kg.

EFFORT = 7914.77 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 5 omit 1976

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	3.2277E+06	4.2399E+06	0.76	0.4641
EFFORT	-966.04	1883.8	-0.51	0.6192
E2	1.3477E-01	2.0489E-01	0.66	0.5255

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	1.541	P VALUE	0.2640
ADJUSTED R SQUARED	0.0827		
R SQUARED	0.2356		
RESID. MEAN SQUARE	1.092E+11		

inverted parabola

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 6 omit 1977

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1.1131E+06	2.9468E+06	-0.38	0.7135
EFFORT	882.68	1358.9	0.65	0.5306
E2	-5.7357E-02	1.5368E-01	-0.37	0.7168

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.887	P VALUE	0.0888
ADJUSTED R SQUARED	0.2392		
R SQUARED	0.3660		
RESID. MEAN SQUARE	2.112E+11		

MSY = 2282764 kg.

EFFORT = 7694.53 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 7 omit 1978

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-5.8139E+05	2.9126E+06	-0.20	0.8458
EFFORT	541.36	1356.7	0.47	0.6466
E2	-3.1355E-02	1.5421E-01	-0.20	0.8430

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.952	P VALUE	0.0846
ADJUSTED R SQUARED	0.2455		
R SQUARED	0.3712		
RESID. MEAN SQUARE	2.063E+11		

MSY = 2698331 kg.

EFFORT = 10227.4 deliveries.

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 8 omit 1979

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1.2955E+06	2.9875E+06	-0.43	0.6738
EFFORT	1033.5	1407.8	0.73	0.4798
E2	-8.2279E-02	1.6333E-01	-0.50	0.6253

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	1.913	P VALUE	0.1915
ADJUSTED R SQUARED	0.1321		
R SQUARED	0.2767		
RESID. MEAN SQUARE	2.093E+11		

MSY = 1949928 kg.

EFFORT = 6280.46 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 9 omit 1980

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	6.0955E+05	2.0143E+06	0.30	0.7684
EFFORT	62.636	937.52	0.07	0.9480
E2	3.3211E-02	1.0638E-01	0.31	0.7613

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	5.852	P VALUE	0.0142
ADJUSTED R SQUARED	0.4471		
R SQUARED	0.5393		
RESID. MEAN SQUARE	9.683E+10		

inverted parabola

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 10 omit 1981

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1.1914E+06	2.9796E+06	-0.40	0.6977
EFFORT	944.31	1382.8	0.68	0.5102
E2	-6.5538E-02	1.5645E-01	-0.42	0.6841

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.930	P VALUE	0.0860
ADJUSTED R SQUARED	0.2434		
R SQUARED	0.3695		
RESID. MEAN SQUARE	2.111E+11		

MSY = 2210144 kg.
EFFORT = 7204.29 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 11 omit 1982

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1.0712E+06	3.3543E+06	-0.32	0.7560
EFFORT	900.50	1617.5	0.56	0.5900
E2	-6.3142E-02	1.9225E-01	-0.33	0.7494

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.075	P VALUE	0.1673
ADJUSTED R SQUARED	0.1519		
R SQUARED	0.2933		
RESID. MEAN SQUARE	2.149E+11		

MSY = 2139472 kg.
EFFORT = 7130.87 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 12 omit 1983

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1.1995E+06	2.9791E+06	-0.40	0.6957
EFFORT	948.43	1382.7	0.69	0.5083
E2	-6.6019E-02	1.5645E-01	-0.42	0.6820

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.936	P VALUE	0.0856
ADJUSTED R SQUARED	0.2440		
R SQUARED	0.3700		
RESID. MEAN SQUARE	2.109E+11		

MSY = 2206790 kg.
EFFORT = 7183.01 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 13 omit 1984

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1.2887E+06	2.9617E+06	-0.44	0.6727
EFFORT	996.07	1377.0	0.72	0.4860
E2	-7.1846E-02	1.5607E-01	-0.46	0.6551

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	2.988	P VALUE	0.0824
ADJUSTED R SQUARED	0.2489		
R SQUARED	0.3741		
RESID. MEAN SQUARE	2.082E+11		

MSY = 2163668 kg.

EFFORT = 6931.98 deliveries

UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 14 omit 1985

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-1.5244E+06	2.8838E+06	-0.53	0.6086
EFFORT	1108.8	1340.6	0.83	0.4275
E2	-8.4195E-02	1.5191E-01	-0.55	0.5916

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	3.264	P VALUE	0.067
ADJUSTED R SQUARED	0.2739		
R SQUARED	0.3950		
RESID. MEAN SQUARE	1.973E+11		

MSY = 2126166 kg.

EFFORT = 6584.71 deliveries

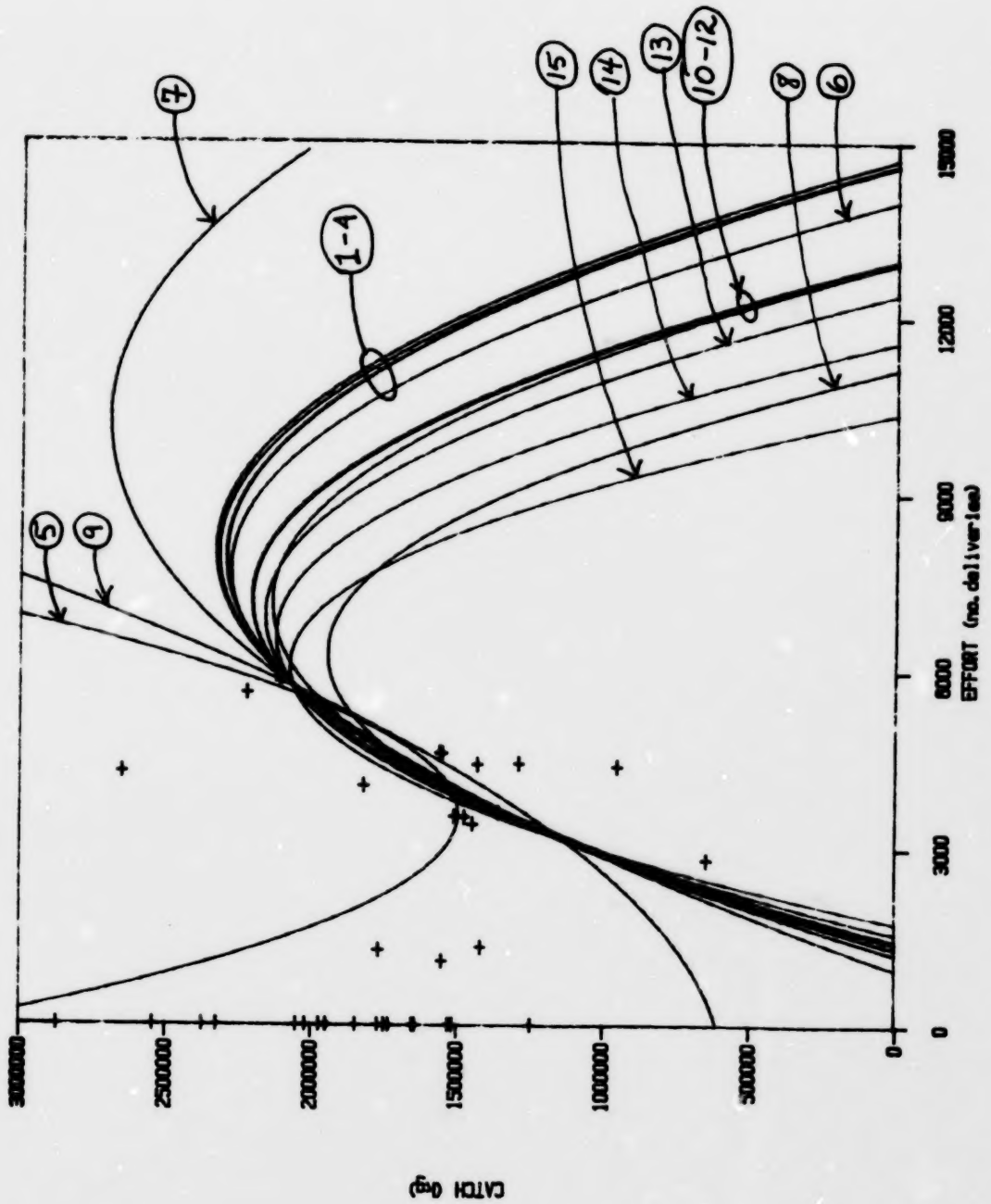
UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF TOTAL curve 15 omit 1986

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	-2.0131E+06	2.5712E+06	-0.78	0.4518
EFFORT	1348.3	1195.8	1.13	0.2859
E2	-1.1108E-01	1.3556E-01	-0.82	0.4316

CASES INCLUDED	13	MISSING CASES	23
DEGREES OF FREEDOM	10		
OVERALL F	4.339	P VALUE	0.0334
ADJUSTED R SQUARED	0.3575		
R SQUARED	0.4646		
RESID. MEAN SQUARE	1.570E+11		

MSY = 2078350 kg.

EFFORT = 6069.05 deliveries


CATCH (kg)
EFFORT (no. deliveries)
0
3000
6000
9000
12000
15000
500000
1000000
1500000
2000000
2500000
3000000
1-4
5
6
7
8
9
10-12
13
14
15